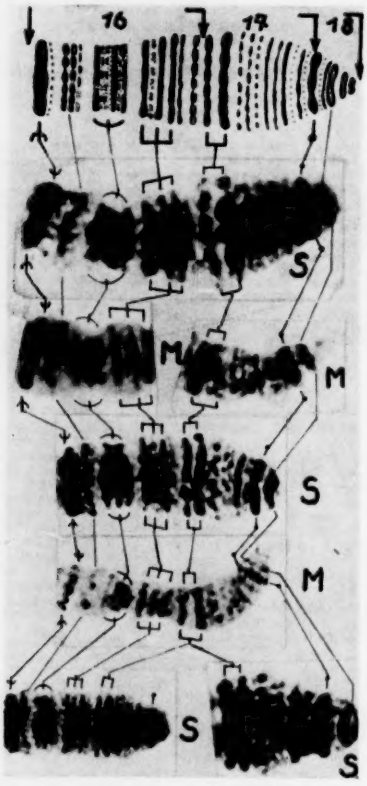
The Journal of HEREDITY



POLYTENE CHROMOSOMES

(SEE PAGE 151)

Blue Minks, Yellow Oats and White Barley

Balancing Populations and Resources Portraits of Human Chromosomes

VOLUME 43 JULY-AUGUST, 1952 NUMBER 4

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

Honorary Emeritus President, DAVID FAIRCHILD

MARCUS RHOADES, President — Vice-President, RONALD BAMFORD

Honorary Vice-President, W. E. CASTLE

WALTER E. HESTON, Secretary — Treasurer, HAIG DERMEN

ROBERT C. COOK, Managing Editor — Assistant Editor, BARBARA LAKE

EDITORIAL BOARD

J. T. BALDWIN, JR. — C. P. OLIVER

C. LEONARD HUSKINS — DELBERT T. MORGAN, JR. — SHELDON C. REED

JAY L. LUSH — JACK SCHULTZ

Members of the Council are ex-officio members of the Editorial Board

COUNCIL

RONALD BAMFORD, Dean of the Graduate School, University of Maryland, College Park, Md.

GEORGE M. DARROW, Horticulturist in Charge of Small-Fruit Breeding, Horticultural Field Station, Beltsville, Maryland.

HAIG DERMEN, Cytologist, Division of Fruit and Vegetable Crops and Diseases, Plant Industry Station, Beltsville, Maryland.

SAMUEL L. EMSWELLER, Principal Horticulturist, Division of Fruit and Vegetable Crops and Diseases, Plant Industry Station, Beltsville, Md.

BENTLEY H. GLASS, Professor of Biology, Johns Hopkins University, Baltimore, Maryland.

WALTER E. HESTON, Geneticist, National Cancer Institute, U. S. Public Health Service, Bethesda, Md.

H. J. MULLER, Professor of Zoology, Indiana University, Bloomington, Indiana.

HUGH C. McPHEE, Assistant Chief of Animal Husbandry Division, U. S. Department of Agriculture, Washington, D. C.

HAROLD H. PLOUGH, Assistant Chief, Biology Branch, Division of Biology and Medicine, U. S. Atomic Energy Commission, Washington, D. C.

MARCUS M. RHOADES, Professor of Botany, University of Illinois, Urbana, Illinois.

LAURENCE H. SNYDER, Dean of the Graduate School, University of Oklahoma, Norman, Oklahoma.

SEWALL WRIGHT, Professor of Zoology, University of Chicago, Chicago, Illinois.

ADVISORY COMMITTEE

E. B. BABCOCK, Genetics Department, University of California, Berkeley.

G. W. BEADLE, Chairman, Division of Biology, Calif. Institute of Technology, Pasadena.

A. F. BLAKESLEE, Professor of Botany, Smith College, Northampton, Mass.

R. A. BRINK, Chairman, Genetics Department, University of Wisconsin, Madison.

LEONARD BUTLER, Professor of Genetics, University of Toronto, Canada.

TH. DOBZHANSKY, Professor of Zoology, Columbia University, New York City.

C. M. GOETHE, Sacramento, California.

C. N. HERNDON, Director, Out-Patient Dept., Bowman Gray School of Medicine, Winston-Salem, N. C.

HARRISON R. HUNT, Professor of Zoology, Michigan State College, East Lansing.

F. B. HUTT, Professor of Animal Genetics, Cornell University, Ithaca, N. Y.

D. F. JONES, Plant Breeder, Connecticut Agricultural Experiment Station, New Haven.

M. A. JULL, Professor of Poultry Husbandry, University of Maryland, College Park.

F. J. KALLMANN, M.D., Research Scientist, New York State Psychiatric Institute, New York City.

C. E. KEELER, Professor of Zoology, Georgia State College for Women, Milledgeville.

L. W. LAW, Senior Geneticist, National Cancer Institute, Bethesda, Md.

PHILIP LEVINE, Director, Biological Division, Ortho Research Foundation, Raritan, N. J.

C. C. LITTLE, Director, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine.

L. F. RANDOLPH, Professor of Botany, Cornell University, Ithaca, N. Y.

PAUL B. SAWIN, Research Associate, Jackson Memorial Laboratory, Bar Harbor, Maine.

KARL SAX, Professor of Botany, Harvard University, Arnold Arboretum, Jamaica Plain, Mass.

JOHN W. SCOTT, Professor of Zoology, University of Wyoming, Laramie.

EDMUND W. SINNOTT, Professor of Botany, Yale University, New Haven, Conn.

RAMSAY SPILLMAN, M.D., New York City.

E. N. WENTWORTH, Armours' Bureau of Agr'l Research and Economics, Chicago, Illinois.

P. W. WHITING, Zoological Laboratory, University of Pennsylvania, Philadelphia.

G. W. WOOLLEY, Head, Division of Steroid Biology, Sloan-Kettering Institute, New York City.

CONWAY ZIRKLE, Professor of Botany, University of Pennsylvania, Philadelphia.

The JOURNAL OF HEREDITY is published bi-monthly by the AMERICAN GENETIC ASSOCIATION at 32nd Street and Elm Avenue, Baltimore 11, Md., and 1507 M St., N. W., Washington 5, D. C. Address all communications regarding editorial matters to 1507 M St., N. W., Washington, D. C. Communications regarding the business management of THE JOURNAL OF HEREDITY may be addressed to the publication office, 32nd Street and Elm Avenue, Baltimore, Md., or to 1507 M St., N. W., Washington 5, D. C. Entered as second-class matter February 24, 1923, at the postoffice at Baltimore, Maryland. Acceptance for mailing at the special rate of postage provided for in section 1103, Act of October 3, 1917, authorized December 29, 1918.

Contents copyrighted 1952 by the American Genetic Association. Unauthorized reproduction of material from THE JOURNAL not permitted. The title "Journal of Heredity" is registered as a trade-mark in the U. S. Patent Office.

$7.00 a Year. $1.50 a copy. Prices of back numbers on application.

The

Journal of Heredity

Vol. XLIII JULY-AUGUST, 1952 No. 4

CONTENTS

Polytene Chromosomes in Different Tissues of *Rhynchosciara*
By C. Pavan and M. E. Breuer 151

Abnormalities in the Mouse
By Orson N. Eaton 159

Mammalian Chromosomes in Vitro
By T. C. Hsu 167

Balancing Population and Resources
By Max Adams 173

Golden Oats
By Darrell D. Morey and R. W. Earhart 181

Three Coincidental Changes in Atom-Bombed Barley
By C. C. Moh and Luther Smith 183

Steelblu, An Allele of Platinum in the Ranch Mink
By Richard M. Shackelford 189

Notes and Reviews

Muscular Hypertrophy and "Black Cutter" Beef
By James F. Kidwell 157

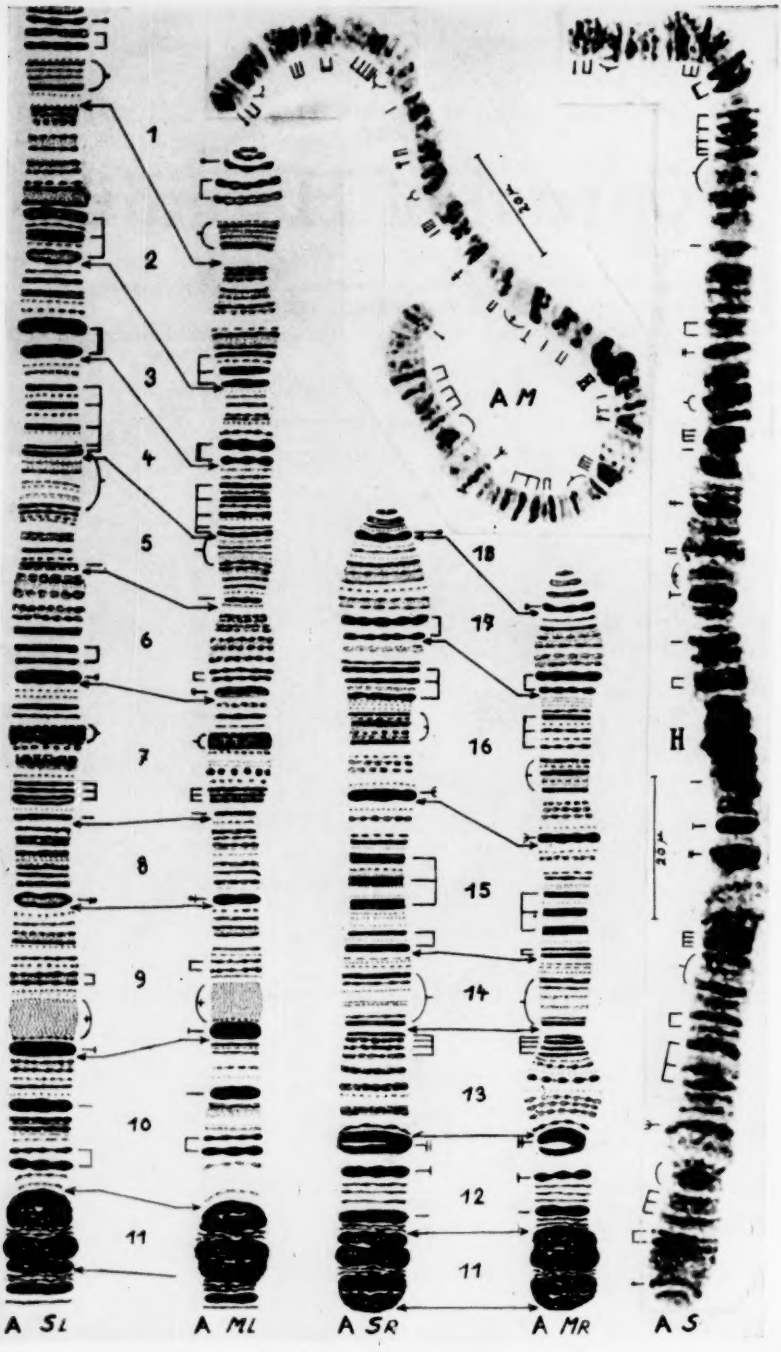
A Nomenclatorial Repeat 158

ONR Seeks Biologist 166

American Tomato Yearbook 173

Ultra-Modern Genetics (Rev. of Srb and Owen: *General Genetics*)
By Thomas W. Whitaker 188

Hereditary Disease Responds to Estrogen Therapy 192



MAPS OF CHROMOSOMES FROM TWO TISSUES

Figure 1

Composite standard maps and microphotographs of the polytene chromosome *A* of *Rhynchosciara angelae* from salivary gland and Malpighian tubule tissues. *ASL* (the left arm), *ASR* →

POLYTENE CHROMOSOMES

In Different Tissues of *Rhynchosciara*

C. Pavan and M. E. Breuer

Department of Biology, University of São Paulo, Brazil

THE body of a multicellular organism arises from a single cell—the fertilized egg. Despite the great diversity of the types of cells in the adult body, it is usually assumed that every cell carries the same gene complement in its chromosomes. As stated by Wright,[10] "The usual and most probable view is that cellular differentiation is cytoplasmic, and must, therefore, persist and be transmitted to daughter cells by cytoplasmic heredity."

A possible approach to this problem is comparative analysis of the polytene chromosomes in different tissues of the same organism. The available cytogenetic evidence shows that, at least in *Drosophila*, the stainable discs in the salivary gland chromosomes correspond to the gene loci in the genetical linkage maps. Thus, differences in the disc patterns in the chromosomes in different organs would indicate corresponding genetic differences. Conversely, similarity of the disc patterns is evidence of similarity of the gene contents.

In 1940, Berger[1] compared the disc patterns in the polytene chromosomes of the salivary gland cells and of the midgut cells of *Sciara ocellaris*, and found these patterns similar. Kosswig[4], Kosswig and Shengün[5] and Shengün and Kosswig[8] contended, however, that the disc patterns in the chromosomes of *Chironomus* are not constant in different cells not only in different tissues but also in the same tissue. Pennypacker[7], working with *Chironomus*, reached the same conclusion as Kosswig and Shengün, but Slizinsky[9] working with *Drosophila* confirmed the observations of Berger.

Rhynchosciara angelae constitutes exceptionally favorable material for studies on the problem under consideration, because of its exceptionally large and clear salivary gland chromosomes, (Nonato and Pavan[6]). The chromosomes in the Malpighian tubes are, in this fly, about as clear as the salivary gland chromosomes in many species of *Drosophila*.

Material and Methods

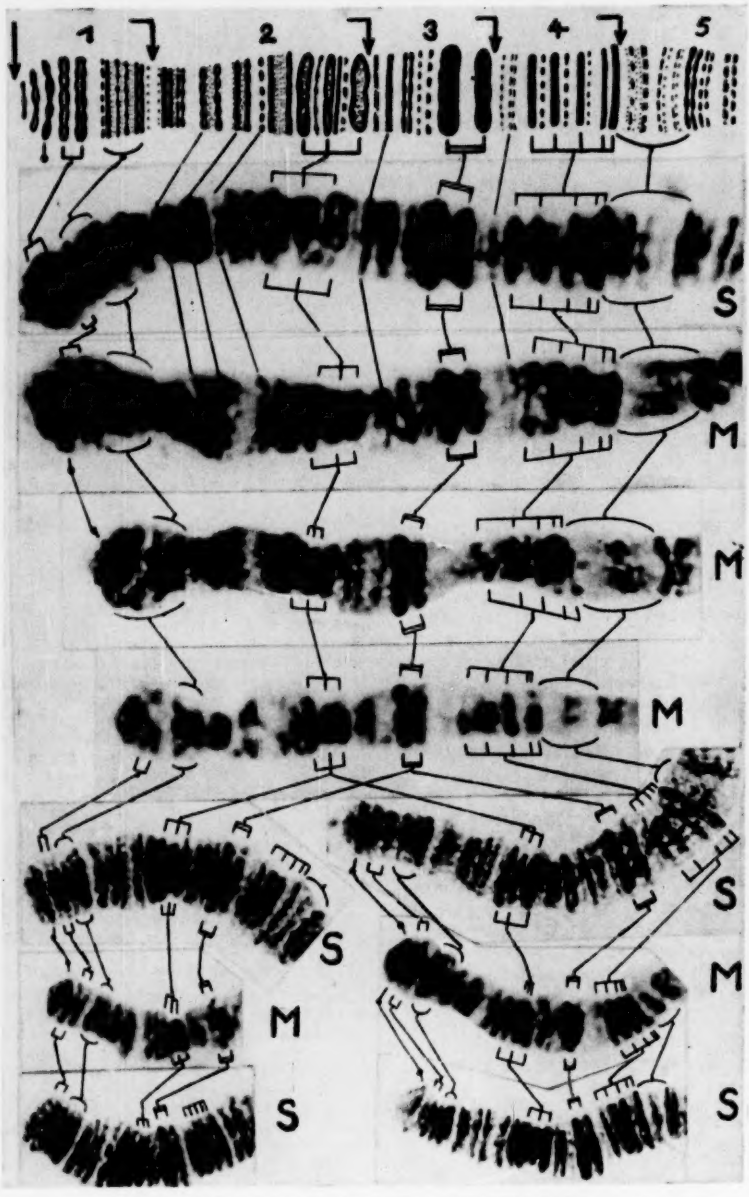
The material used in this study consisted of larvae of *Rhynchosciara angelae* which were collected under decayed vegetation in a banana orchard (Fazenda Santa Cruz at Vila Atlantica, near Praia Grande, State of São Paulo, Brazil). The larvae of this species are gregarious; they live together from the egg to the pupal stage. Some of the groups of larvae consist of about 500 individuals, but a majority of such groups include from 100 to 150 individuals. The larvae were abundant in September, 1950, but very scarce from December, 1950, to July, 1951. Nevertheless, we were able to collect enough larvae and to have a supply of developing larvae in the laboratory almost continuously.

The slides of the salivary glands, the Malpighian tubules (from the larvae as well as from the adults), and of the vesiculae seminales were prepared as aceto-orcein smears, and analyzed in temporary preparations or after having been made permanent in diaphane.

Chromosomes of *Rhynchosciara angelae*

As was shown by Dreyfus *et al.*[3], *R. angelae* is a dipteran of about seven to 10 mm. in body length, and with larvae of about 10 to 15 mm. long. In the pre-pupal stage the larva has a salivary gland about 10 to 15 mm. in

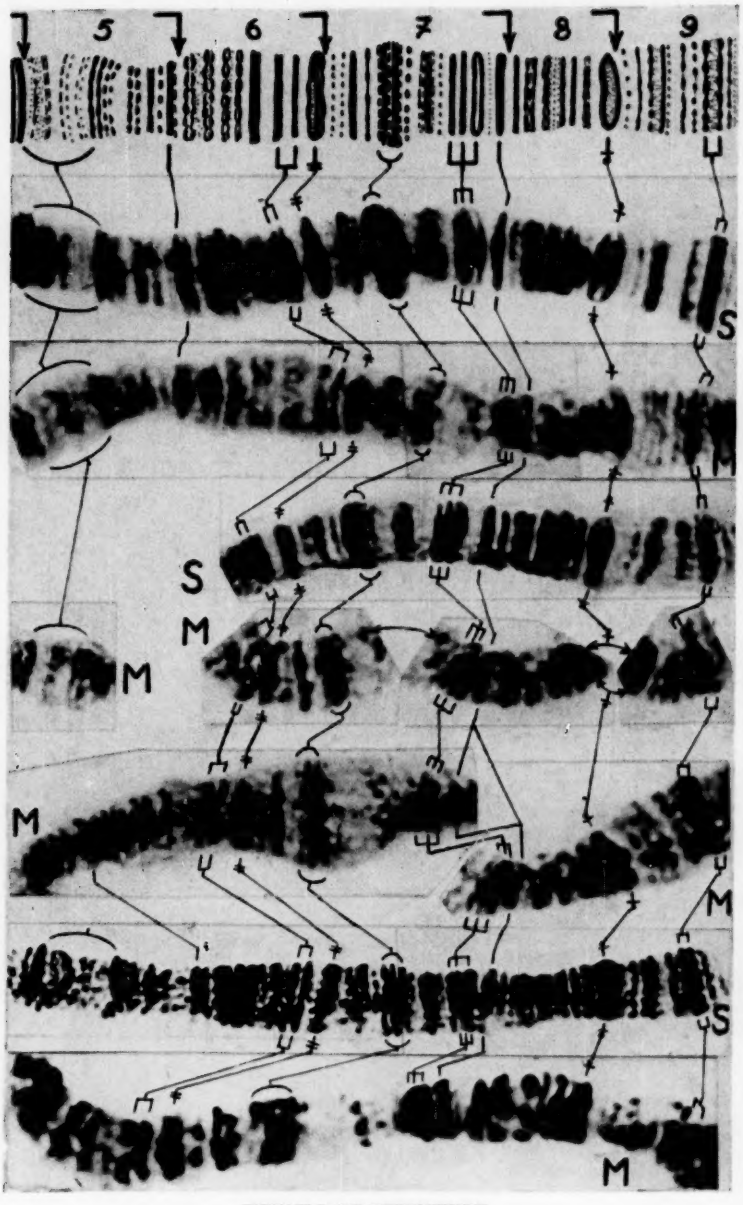
(the right arm) and *AS* (a microphotograph of the entire chromosome) show the topography of this chromosome from salivary gland material. The symbol *H* in the microphotograph shows the location of the heterochromatic region. The right arm extends down from the heterochromatic region, the left arm up. *AML*—left arm, *AMR*—right arm, *AM*—a microphotograph of the chromosome show the *A* chromosome from Malpighian tubule cells. The numbers from 1 to 18 represent the sections into which the chromosome is arbitrarily divided. The symbols at the side of the chromosomes indicate the main landmarks. The two scales adjoining the microphotographs represent 20 microns.



COMPARISON OF SALIVARY AND MALPIGHIAN TISSUE

Figure 2

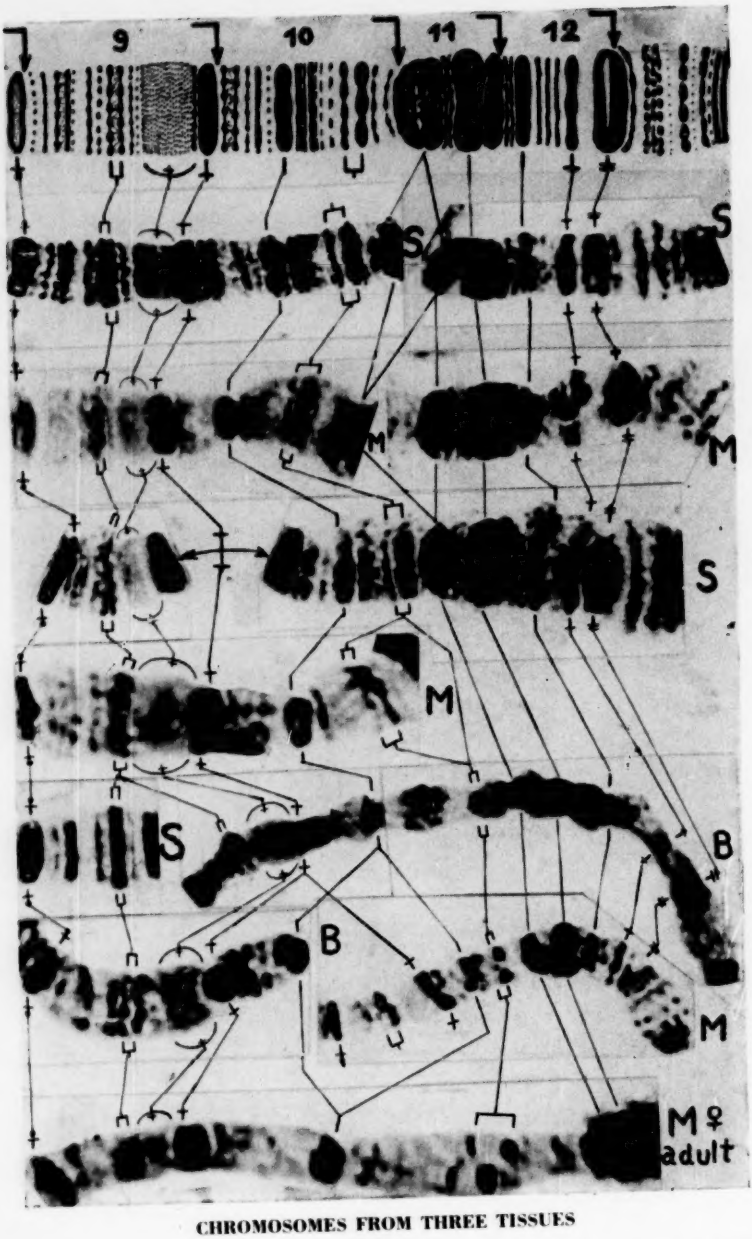
A detailed map of sections 1 to 5 of chromosome *A* (Figure 1) is shown at the top of the plate. Microphotographs of this area from five salivary gland cells (*S*), and from five Malpighian tubule cells (*M*) are shown below. The lines connect corresponding landmarks.



DETAILS OF STRUCTURE

Figure 3

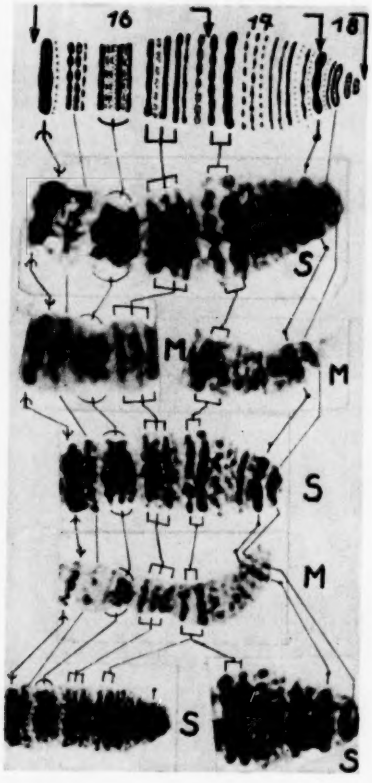
A standard map of sections 5 to 9 of chromosome *A* are shown at the top of the plate, and below it microphotographs of this section of the chromosome from salivary gland cells (*S*) and from Malpighian tubule cells (*M*). The lines indicate the corresponding landmarks.



CHROMOSOMES FROM THREE TISSUES

Figure 4

The standard map of sections 9 to 12 of chromosome *A* is shown at the top, and microphotographs of salivary gland cell chromosomes (*S*), Malpighian tubule cell chromosomes (*M*), and vesiculae seminales cell chromosomes (*B*) are shown below. The connecting lines show the main landmarks, which can readily be identified.



DISTAL END OF CHROMOSOME *A*

Figure 5

Sections 16 to 18 of chromosome *A* are shown. The arrangement and description are the same as in the preceding Figures.

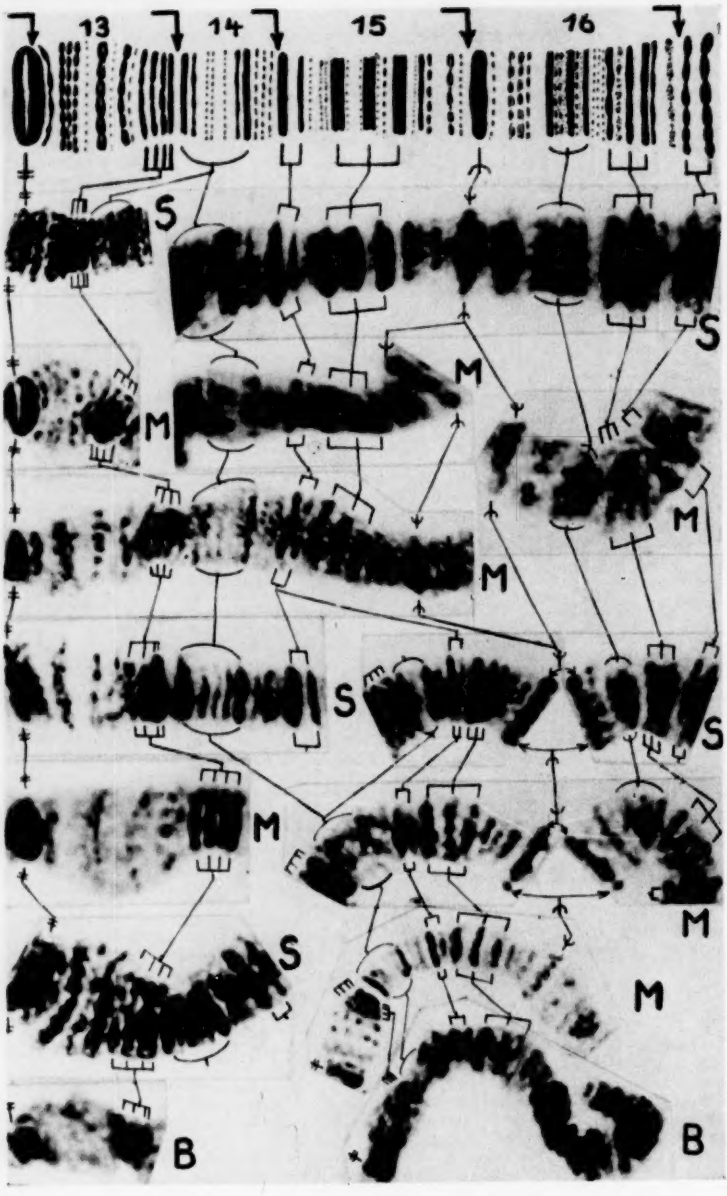
length. The basal parts of the Malpighian tubules have some cells with voluminous nuclei from which very good preparations of polytene chromosomes can be made. Cells with large nuclei and large polytene chromosomes can be found also in some part of the vesiculae seminales. In all these cells the nucleus has four polytene chromosomes, three single-armed elements, and a large chromosome with two unequal arms. For the detailed comparisons we have used only this last element, which was called by Dreyfus *et al.*[3] chromosome *A*.

The largest polytene chromosomes are found in the nuclei of the salivary glands. The Malpighian tubule chromosomes are about two-thirds as long as the salivary chromosomes, and are approximately one-half as wide. The chromosomes in the vesiculae seminales are still smaller than in the Malpighian tubules. It is easy to compare the banding patterns of the chromosomes from the Malpighian tubules with those from the salivary gland cells and to observe that they are alike. In some cases where there was some doubt about some very faint bands, it was a simple matter to settle the question by making a new preparation, and each time we have had the same result: every band from one chromosome was found in the other. Although more difficult, it was possible to compare the chromosomes of the Malpighian tubules from adult flies with the chromosomes from the salivary gland cells of the larvae. The same correspondence of banding was found.

The polytene chromosomes from the vesiculae seminales are not as favorable as the others for study, and the comparison is possible only with some difficulty. However, when the chromosomes were well spread, it was always possible to follow the banding patterns with the aid of a drawing of the Malpighian tubule chromosomes or of those of the salivary gland cells. The best part of the chromosome for such comparisons is the region close to the heterochromatic part (from section 9 to section 13, see Figures 1 and 4).

Although the chromosomes of the salivary gland cells are most favorable for study, the heterochromatin is more differentiated in the Malpighian tubule cells than in those of the salivary glands. In the salivary glands, the heterochromatin very often appears to be rather similar to the euchromatin. Another peculiarity of the heterochromatin in *R. angelae* is that it seems to have a nonspecific attraction, and tends to form a chromocenter, as observed by Dreyfus *et al.*[3], in the Malpighian tubules and in the vesiculae seminales. In the salivary glands, however, no such chromocenter is formed, and the heterochromatic areas, in comparable positions in the chromosomes, form isolated blocks, which show no mutual attraction. Undoubtedly, the behavior of the discs in section 11 (see Figure 1) are different from the bands of the other sections. Sometimes these bands have sharp edges and at other times they have very irregular forms, the bands almost fusing together and forming a compact block.

For the purpose of description, the chromosome *A* of *R. angelae* is divided into 18 arbitrary sections, beginning with section 1 at the distal end of the left arm of the chromosome. The left arm is longer than the right one. The best landmarks in the chromosome are the two heavy discs in section 3; the heavy discs in section 8, close to the boundary with 9; the part of section 9 close to 10; the sections 10, 11, and 12; the four discs in section 13; and the heavy disc in section 16, at the boundary of 15.



DETAILS OF MID-SECTION OF CHROMOSOME *A*

Figure 6

Sections 13 to 16 of chromosome *A* are shown. The arrangement and description are the same as in the preceding Figures.

Conclusions

The disc patterns in the polytene chromosomes of *Rhynchosciara angelae* are recognizably similar in the cells of the salivary glands, of the Malpighian tubes, and of the vesiculae seminales. Thus the results of the present investigation are in accord with the observations of Berger[1] on *Sciana ocellaris* and of Slizinsky[9] on *Drosophila melanogaster*.

The principal variations from cell to cell are observed in section 11, which lies close to the chromocenter. The discs in this section have sharp outlines in some cells, while in others they tend to be indistinct. A similar condition of the discs close to the boundary of euchromatic and heterochromatic regions has been observed by Dobzhansky[2] in *Drosophila pallidipennis*.

No chromocenter is formed in the cells of the salivary glands, but in the Malpighian tubes and in the seminal vesicles the chromosomes tend to be associated in the heterochromatic regions.

Literature Cited

1. Berger, C. A. *Jour. Hered.* 31:2-4. 1940.
2. Dobzhansky, Th. *Amer. Natur.* 79: 193-213. 1944.
3. Dreyfus, A., E. Nonato, M. E. Breuer, and C. Pavan. *Rev. Brasil. Biol.* 11:439-450. 1951.
4. Kosswig, C. *Proc. 8th Internat. Cong. Genetics*, 609. 1948.
5. Kosswig, C., and A. Shengün. *Jour. Hered.* 38:235-239. 1947.
6. Nonato, E., and C. Pavan. *Rev. Brasil. Biol.* 11:435-437. 1951.
7. Pennypacker, M. *Jour. Hered.* 41:155. 1950.
8. Shengün, A., and C. Kosswig. *Chromosoma* 3:195-207. 1948.
9. Slizinsky, B. M. *Jour. Genet.* 50:77-78. 1950.
10. Wright, S. *Physiol. Rev.* 21:487-527. 1941.

(Received February 8, 1952)

MUSCULAR HYPERTROPHY AND "BLACK CUTTER" BEEF

Kidwell *et al.*[3] described an anomaly of cattle called Muscular Hypertrophy. They found that anomalous animals were abnormally thick and full in the thighs, with a deep groove between the thigh muscules. The twist was found lacking in depth and fullness as the muscling did not extend toward the hocks as far as in normal animals. They observed heavy muscling over the withers. Subcutaneous fat was neglible, with little internal fat present. Such carcasses are known in the meat trade as "Teeswaters" or "Yorkshires," etc. Wriedt[4] emphasized the variable expression of the trait.

Guilbert[2] described "black cutter" beef, an anomalous condition encountered in beef carcasses. There is some evidence which indicates a common genetic origin of these anomalies.

Cut surfaces of some carcasses or parts of carcasses ("dark" or "black cutters") do not brighten normally, apparently because muscle hemoglobin fails to change to oxyhemoglobin. Age, exercise, excitement, feed, delayed bleeding, peculiar pigmentation, and heredity, have been ascribed as contributing factors. As dark or black cutting beef had not been produced experimentally by any of the other methods, Guilbert concluded that a hereditary basis would be a logical field of investigation.

Reference was made to a book written by George Culley in 1807,[1] with observations as far back as 1774 which present an historical basis for a genetic explanation of the black cutter anomaly. Several quotations from Culley's book are of interest. Referring to the "Shorthorn or Dutch Kind" and their continental origin, he states, "I remember a gentleman of the County of Durham (Mr. Michael Dobinson), who went in the early part of his life into Holland in order to buy bulls, ... But afterwards, some other persons of less knowledge going over, brought home some bulls, that in all probability introduced along that coast the disagreeable kind of cattle, well known to the breeders adjoining the river Tees, by the appellation of lyery, or double-lyered; that is black fleshed; for, notwithstanding one of these creatures will feed to a vast weight and though fed ever so long, yet will not have one pound of fat about it, neither within or without, and the flesh (for it does not deserve to be called beef) is as black and course grained as horseflesh."

Referring again to Shorthorns, Culley wrote, "This breed, like most others, is better and worse in different districts; not so much, I apprehend, from the good or bad quality of the land, as from a want of attention in the

breeders. In Lincolnshire (which is the farthest South that we meet with any number of this kind of cattle) they are, in general, more subject to lyer, or black flesh, than those bred farther north; and in that rich part of Yorkshire called Holderness, they are much the same as those south of the Humber, of which we have been speaking."

These quotations may indicate an historical genetic link between the muscular hypertrophy and black cutter anomalies. A genetic relation may exist between the abnormalities; first, reference has been made to the absence of fat, "neither within or without," which is also characteristic of muscular hypertrophy. The animals Culley described as lyery were almost certainly also afflicted with muscular hypertrophy.

Second is the location of "lyery or black-beefed" animals in herds found near the river Tees and in Yorkshire, and reference to carcasses with muscular hypertrophy as "Tees-waters" and "Yorkshires," indicating a common origin.

Finally, the inference that the anomaly was due to "want of attention in the breeders" indicates the trait may be inherited.

These early observations indicate the possibility of a common genetic origin. It is possible that the two conditions resulted from a single gene acting in a plieotropic manner. The observations could also be explained by two linked genes. However, if either of these hypotheses is true, it seems likely that modern investigations would have found the traits occurring together. Although large variation of expression of both anomalies has been stressed, it does not seem sufficient to account for the failure to observe both traits in the same animal.

The observations seem to indicate the hypothesis that the traits are conditioned by independent genes. The anomalous alleles occurred together in older European cattle, but have become separated during modern American development. The separation may have been the result of chance. However, it is certainly suggestive that the separation resulted from selection for animals heterozygous for muscular hypertrophy and against black cutters.

It is hoped that this note will stimulate sufficient interest among cattle breeders that data leading to a proven hypothesis may be collected.

Literature Cited

1. Culley, George. Observations on Livestock. Fourth edition. Printed by G. Woodfall, Paternoster-row, London. 1807.
2. Guilbert, H. R. *Jour. Hered.* 28:6-213-215. 1937.
3. Kidwell, J. F., E. H. Vernon, R. M. Crown and C. B. Singletary. *Jour. Hered.* 43:63-68. 1952.
4. Wriedt, C. *Zeitschr. fur Ind. Abst. U. Vererbungslehre.* 51:482-486. 1929.

James F. Kidwell
University of Nevada
Reno

A Nomenclatorial "Repeat"

THE Managing Editor of the *Journal of Heredity* wishes to point out that there are two "Robert C. Cook's" abroad in the land. For more than 30 years one of them has directed as best he could the destinies of that *Journal*. The other has meanwhile published a directory of teachers from an address in Nashville, Tennessee.

In order to get names to fill his directories the latter Robert C. Cook has bombarded the teaching profession with questionnaires. In the 1930's biologists complained that these importunings reflected on the *Journal* which it was assumed the directory-publishing Mr. Cook edited. The *Journal of Heredity* received so many letters of protest that Managing Editor Cook felt constrained to publish in his *Journal* of May 1936 a note disclaiming any connection whatever with the teacher-directory business.

Now, 16 years later, history repeats itself. The directory-publishing Mr. Cook has launched a venture entitled "Leaders in American Science." This involves a more extensive canvass of biologists, and is yielding a proportionate number of protests addressed to the *Journal of Heredity*.

For the record, then, the undersigned wishes to once more make it clear that he has no connection—either genetic or economic—with the directories published in Nashville, Tennessee, and has no voice in determining the policy connected with them. He can do no more than disclaim any involvement in this venture, and regrets any perturbations his friends may have felt as a result of this confusion in identity.

Robert C. Cook
Managing Editor
Journal of Heredity
Washington, D. C.

ABNORMALITIES IN THE MOUSE*

ORSON N. EATON†

United States Department of Agriculture

The manuscript concerning inherited abnormalities in mice presented below was originally submitted for publication in 1949. It was decided that due to our heavy commitments at that time and because of the detailed nature of the presentation, it would not be possible to publish the articles in full. Dr. Eaton undertook to prepare a summary of these articles for publication, the full tabular data and detailed discussion to be made available as supplementary documents.‡ This Dr. Eaton has now done.

As Dr. Eaton points out in a footnote, considerable new data regarding the inheritance of tail defects in mice has been published since the article was originally submitted.—ED.

I. *Tail Anomalies*

SEVERAL more or less closely related anomalies of the tail of the laboratory mouse have been described by various authors. Among them are short tail (brachyury)[11] taillessness (anury)[12] and fused tail.[22] Other short-tailed abnormalities[13,20] and the kinky tail[6] also may be related to this group. All the foregoing types of tail anomalies are dominant in inheritance. Two recessive types also have been reported, flexed,[18] and pigtail.[10] Brachyury and anury are due to a series of four alleles (T, t^c, t^1, and t) while fused (Fu) and kinky (Ki) are due to separate genes located close together on the same chromosome with the T series.[14,16]

Tail anomalies similar to the ones mentioned above have been observed in the mouse colony until recently maintained by the Bureau of Animal Industry for genetic experiments.

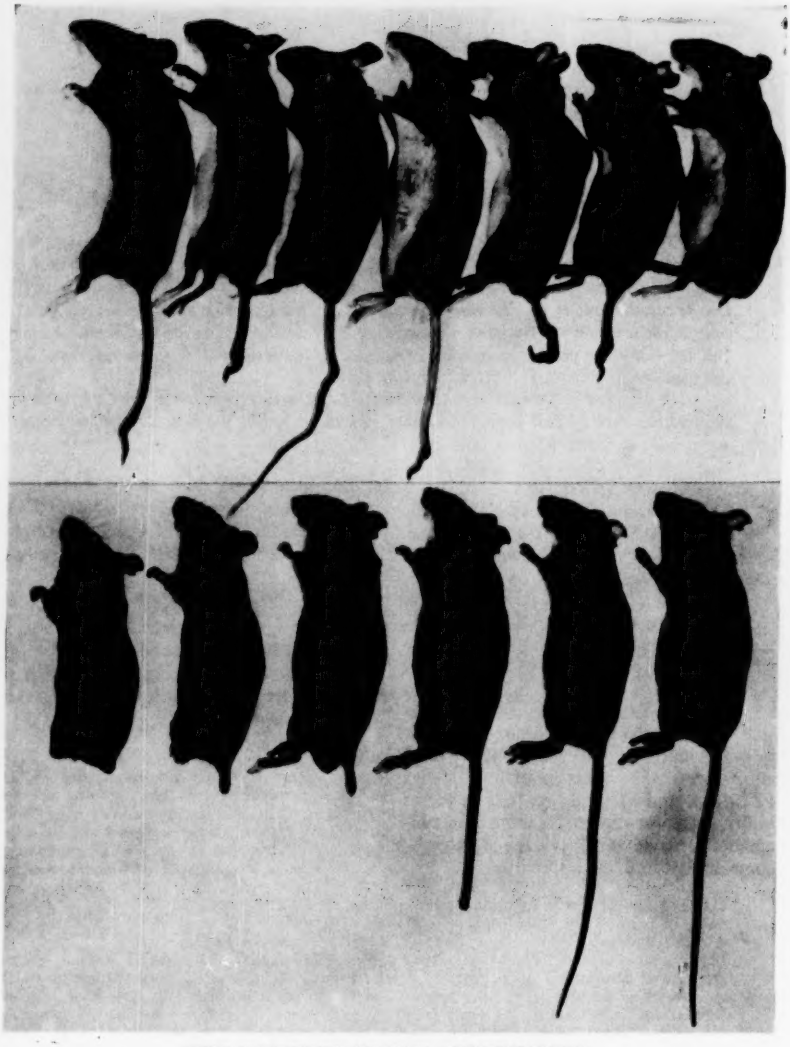
In some the tail was only a short filament of skin about 3 mm. long. Others were less than half normal length, ending in a somewhat bulbous swelling with a thin bent tip or with a double flex at the end and a thin bent tip (Figure 7). Others were tailless.

Pedigrees of the abnormal-tailed mice showed there were two large groups wholly unrelated. The first group included litter 7142 and its descendants and contained 111 individuals with abnormal tails. The characteristic appearance of the tails of this group was as

*The data for this series of papers were collected as an incidental part of a study of inbred line crosses in relation to hybrid vigor in mammals. Record is being made of these observations here in order that they be available to other workers in animal breeding.

†The author is animal husbandman, Animal Husbandry Division, Bureau of Animal Industry, Agricultural Research Administration, Washington, D. C. Since the material contained in this paper was first written, there have appeared in the JOURNAL OF HEREDITY five other articles on tail mutations in the mouse, variously described as loop-tail, short-tail, vestigial tail, pin tail, and hook-tail. These resemble in many respects the mice described in the present paper, and it seems possible that some, at least, may be merely variations in expression of a gene, perhaps with modifiers, which may be responsible for a whole series of these tail anomalies. The issues of the JOURNAL in which these articles appeared are Vol. 40(12):329, 1949; 41(8):208, 1950; 42(2):71, 1951; 42(4):179, 1951; 42(6):305, 1951.

‡Thirty-one pages of detailed description and extensive tabular data of the three abnormalities reported herein are available as supplementary documents. To obtain this material, order Document No. 3697 with respect to Tail Anomalies; Document No. 3698 with respect to Polydactylism and Syndactylism; and Document No. 3699 with respect to Hydrocephalus, from the American Documentation Institute, 1719 N Street, N.W., Washington 6, D. C. Remit with order $1.00 for Document No. 3697; $1.00 for Document No. 3698; and $1.00 for Document No. 3699 for microfilm (images one inch high on standard 35mm. motion picture film) or $2.25; $1.20; $1.05 respectively for photocopies (6 × 8 inches, readable without optical aid).



TWO PATTERNS OF TAIL ABNORMALITY

Figure 7

Abnormal-tailed mice of group 1 are shown at the top. The three on the right are ♀7240 and ♀7245 and ♂7247, from litter 7142. The four on the left are daughters of 7240 mated to a normal-tailed male descended from strains *b*, A^s, and a^t. Abnormal-tailed mice characteristic of group 2 are shown below. These are a single litter from a back-cross mating, Cin × (Cin × CdE). The two animals at the right have normal tails. The two animals shown at the left were born without hind legs.

described above. The tails of the second group were, for the most part, merely shortened several segments and without flexures (Figure 7). A few, however, showed flexures, but less severe than those of group 1. The parents of the foundation litter of group 1 were from two unrelated strains in group 2, the sire being from a strain of brown mice

built up from the Jackson Laboratory C57 brown strain, the dam a descendant of a cross between A^y (not in A^y 7800 line) and a^t mice from the University of Maryland. Figure 8*A* shows the lines of descent of groups 1 and 2 and how they tie in with each other.

Since there were so few matings of some tail types, it was decided, for the purposes of analyzing the data, to consider the matings as affected × affected, affected × normal, and normal × normal. In affected × affected matings of group 1 the numbers of progeny with normal and abnormal tails were nearly equal, whereas there were nearly twice as many normal tails as abnormal from normal × affected matings. The normal × normal matings consisted of normal litter mates of the three abnormal-tailed mice in litter 7142 mated *inter se* with unrelated normals, and descendants of these litters. The greater number of the affected mice of this group were of the short flexed-tail type; next in frequency were tailless. In group 2 there were only 13 litters whose parents had defective tails. Most of the affected mice in this group were produced by normal parents and the type of abnormality was quite different from that of group 1.

Results are given in Table I* for the mice of groups 1 and 2.

Sex distribution and litter size are shown in Table II. In group 1 the average litter size in normal × normal matings was more than twice that in affected × affected matings. In affected × normal matings litter size was between that of the other two types of matings. This finding suggests that some of the young apparently died before birth. Also, the number of young dying before 30 days when compared with the death rate from normal matings suggests an inherent weakness of young from abnormal-tailed mice. The percentage of young born dead or who died before 30 days of age in normal matings in group 1 was 5.03, whereas that from affected matings was 15.59. The death rate in these matings was equal for both normal and affected mice. The difference between mean litter size in the differnt types of matings of group 1 is highly significant when judged by the *t* test. Sex ratio seems somewhat erratic. However, using the ratio of 1 male; 1.02 females, which is the value for normal matings, the sex ratio in the other two types of matings did not differ significantly from this value, either in group 1 or 2. In group 2, litter size did not differ significantly in normal × normal and normal × affected matings.

Discussion

The data in the present paper indicate that the character is dominant in group 1 mice. The fact that litter size in affected × affected matings is less than half that in normal × normal matings, suggests that approximately one-half the young must have died before birth. This is the case in certain matings of the *T* series. Various types of heterozygous matings should produce ratios of 1:1 and 2:1 abnormal-tailed to normal-tailed mice.

In group 2 the greater number of abnormal-tailed mice were produced by normal parents. They were not confined to a single series of closely related matings like those of group 1, but were more or less sporadic in their occurrence. However, 60 of the 141 affected individuals in this group traced back to a single male and two or three females to which he was mated. The remaining affected mice were from crosses between unrelated strains.

The above facts bring up the question whether two or more types of tail abnormalities are not represented.

Since the tails of some of the mice resembled those described by Danforth, examination was made for kidney and ureter malformations. Of the 29 mice examined, only three had defective kidneys or ureter. Danforth (reported by Dunn *et al*,[14]) reported a high death rate among the mice of his short-tailed strain. In group 1 mice of the present paper, mortality between birth and 30 days from affected matings was 15.6 percent. From normal matings the death rate was five percent between birth and 30 days. This is much lower than Danforth reported, his mortality rate reaching as high as 70 per cent by 30 days. In group 2, mortality from affected matings was nearly twice that from normal matings, being 7.6 and 3.9 percent, respectively.

Insufficient data are available from group 2 to determine if the tail defect is dominant or recessive. In several instances, 50 percent or more of the members of the litter were affected.

Summary

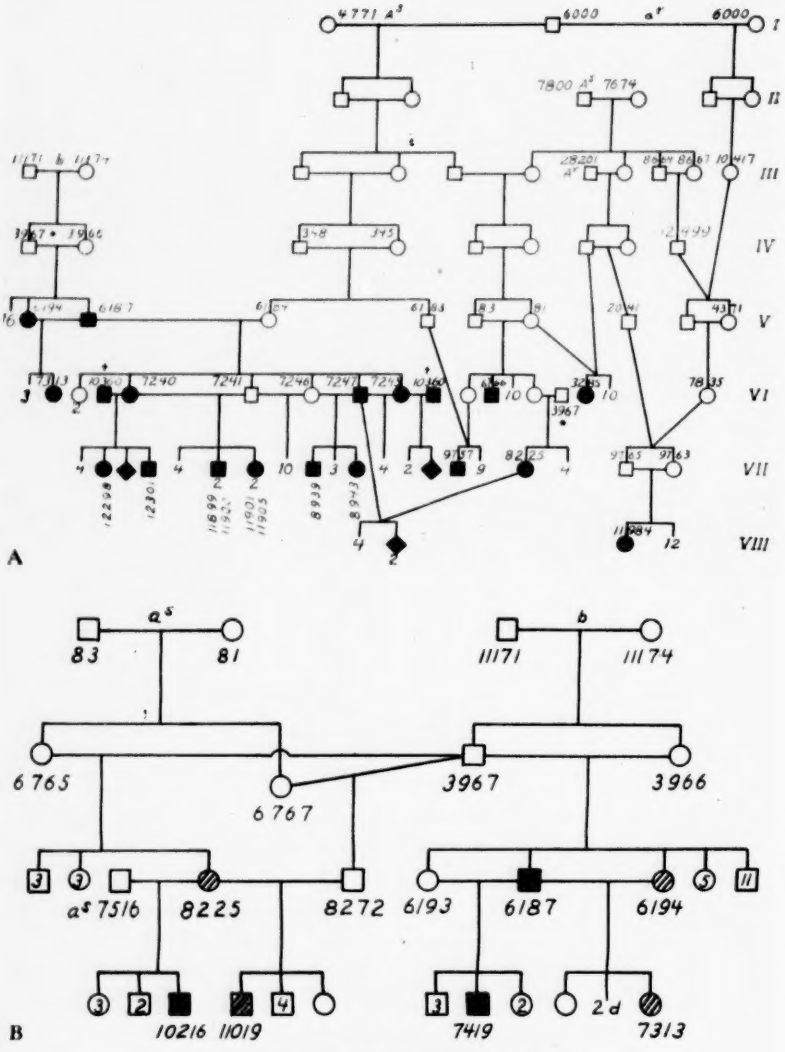
Description is given of tail anomalies arising in a colony of mice maintained by the Bureau of Animal Industry. The abnormality is manifested by shortening of the tail with various kinks, coils, spirals, and even complete absence of the tail or only a short thin filament present.

Two types of abnormalities appear to be present. One is dominant in inheritance, the ratio of abnormal to normal tail in matings of affected × affected being 1:1. In matings of normal × affected, the ratio averaged 1:2.

Variations in litter size in different types of matings indicate a high prenatal mortality in affected matings. The percentage of young born dead or who died before 30 days of age was three times as great in affected as in normal matings.

The mode of inheritance of the second type of abnormality is uncertain. There appears to be less effect of the abnormality on litter size than in the first group.

*The Tables referred to in this section on Tail Anomalies will be found in Supplementary Document No. 3697.



PEDIGREE'S OF TAIL-DEFECTIVE MICE

Figure 8

A—shows the main sources of ancestry of groups 1 and 2 and how the lines tie in with each other. Solid squares and circles indicate affected individuals. A diamond indicates sex unknown. Sires appearing twice are indicated by * and +. Numbers with one or two digits immediately below sib lines indicate number of normals regardless of sex. Other numbers and letters indicate identification number of animal and strain. Many other affected individuals appeared as descendants of generations 6 and 7. *B*—shows the dominant mutation in strain *b* which gave rise to the foundation litter of group 1. Solid squares indicate tailless; hatched squares represent the flex-tailed mice. Numbers within circles and squares indicate normal mice.

Sex ratio was normal for affected mice of both types of abnormality.

Pedigrees of the abnormal-tailed mice indicate several sources of origin unrelated to one another, and possibly arising as separate mutations.

II. *Polydactylism and Syndactylism*

Polydactylism is a rather widespread phenomenon, occurring in several species of mammals, including man, and in poultry. It has been reported in mice by various authors. There is a wide variation in the expression of the character, ranging from the articulation of the extra digit on the tarsal bone to a mere exostosis on the distal phalanx. In most cases the first toe is duplicated. There is a tendency for the anomaly to appear more often on one side than on the other. A type of polydactylism which involved the anterior legs has been reported.[24] Only a rudiment of a claw was present on the outside of the hand. One or both legs were affected. Besides these cases there is a polydactylism of the hind feet due to myelencephalic blebs.[1,2] The embryological basis for this defect has been investigated extensively by Bonnevie.[3, 4, 5]

The present report deals with the sporadic occurrence of polydactylism in mixed strains of mice maintained by the Bureau of Animal Industry for genetic experiments.

The polydactylous animals were all from mixed strains of mice used in cross-breeding experiments. They appeared at various times from February, 1939 through January, 1948. Only two of the animals were from a single sire and dam, occurring in two succeeding litters. The others were from separate matings, none of which were closely related.

The extra digit varied considerably in expression. In some individuals it appeared as a complete toe articulating from the base of the first toe. It was as large or larger than the first toe and had a nail in every case except two. In others it was small and appeared to be an outgrowth from the side of the first toe. On two animals there were seven toes, the two extra ones being considerably larger than the first toe itself. In several instances the first toe stood out almost at a right angle from the axis of the foot.

In the 22 litters produced by the matings in which the 18 polydactylous animals occurred, there was a total of 173 young. In 13 cases the extra digit was on the right foot. In one case both feet were affected. Only the hind feet were involved (Figure 9). There were twice as many females as males that were affected. This fact probably is merely chance due to small numbers. The parents and ancestors back to 1938, when the stock was procured were all normal. Only one mating was made, both members of which were polydactylus. Two litters consisting of 16 normal young were produced. Table I gives the data for the polydactylous matings.*

There are not sufficient data to determine the nature of the heritability of the defect in the present report. Eleven of the polydactylous animals were in three main lines of descent, four from a^t stock procured from the University of Maryland, four from a cross of inbred strains B and Cd, and four from a brown strain built up from strain Br. The B, Cd and Br strains were built up from Jackson Laboratory stock. Most of the polydactylous animals traced six to eight generations within their respective lines before there was a common ancestor; thus there was little relationship between the affected individuals. The remaining polydactylous animals were unrelated and had several mixed strains in their ancestry. There was only a single occurrence in which a mating produced two polydactylous animals. Whether matings of the polydactylous animals would have increased its incidence is a question, since only one such mating was made and all the young were normal. The polydactylous animals were all produced by normals.

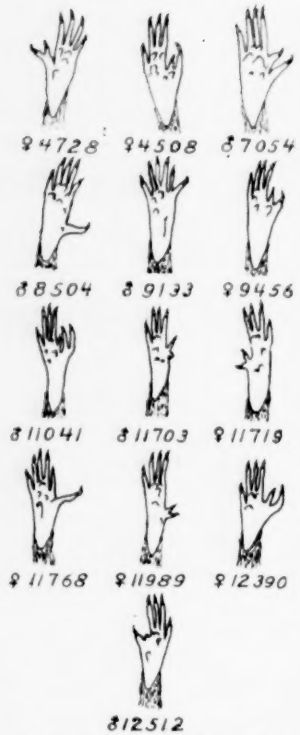
The several lines of ancestry involved in the polydactylous matings suggest that it was a sporadic mutation. There is further parallelism to other reported cases in that only the hind feet were affected and that the extra toe appeared on the right foot more frequently than on the left. There was some variability of expression. The abnormality appeared as a doubling of the first toe with one case in which a seventh toe was likewise derived from the first. This type of polydactylism appears to be different than that in poultry and guinea pigs. In these two species the extra toe appears to be an attempt toward restoration of the pentadactyl foot. In the mouse, however, which already has a pentadactylous hind foot, the extra toe is probably not the restoration of a lost structure, but is the duplication of one already existing.

Syndactylism

Syndactylism in mice occurs less frequently than polydactylism, but is traceable to the same cause that produces some types of polydactylism.[16]

In the mouse colony of the Bureau of Animal Industry only three apparent cases of syndacty-

*The Tables referred to in this section on Polydactylism and Syndactlyism will be found in Supplementary Document No. 3698.



VARIED SYNDACTYLISM

Figure 9

Diagram of the differences in expression of polydactylism. Diagrams were not made of the first five cases recorded.

lism were found among more than 7,950 litters. These occurred at widely separated intervals and were not closely related. One case was recorded as having three toes on the right front foot. It was not indicated in the records whether there was a fusion of two toes or whether one was completely absent. This case was in strain B, coming from the Jackson Laboratory C57 black stock.

Case *2* showed a fusion of toes two and three of the right hind foot. This was in a backcross mating of strains W × S/W. W is an A^w strain from the Jackson Laboratory stock and S an albino Swiss strain procured from Ohio State University.

Case 3 was remotely related to case 2, the common ancestor being an S male removed 5 generations in case *2* and 6 generations in case 3, from the affected individuals. In this case toes two, three, and four of the left hind foot were fused.

The female with the three toes of case 1 was mated to two different normal males and produced three litters. Two litters each contained six normal young by a silver male and one litter had six normal young by a C strain male. The matings producing the syndactylous mice were not related to those producing polydactylism.

Sixty mice were produced in nine litters involved with the production of syndactylism. Five percent of these animals were syndactylous.

Since there was no relationship between the polydactylous and syndactylous matings, it is reasonable to assume that they are independent of each other in these strains. Whether myelencephalic blebs were involved in the production of either anomaly was not investigated.

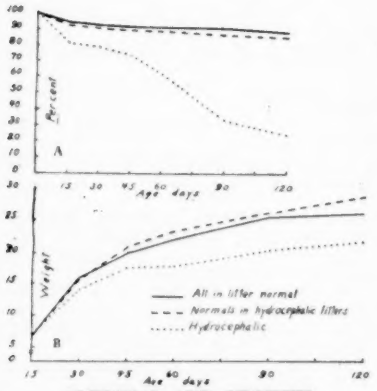
Summary and Conclusion

An account is given of the sporadic appearance of polydactylous mice from unrelated mixed matings. The abnormality appeared as a doubling of the first toe with variability in expression. The right foot was affected more often than the left. Twice as many females as males were affected. All polydactylous animals were produced by normals. The question of the mechanism of its development and heredity is one that needs further investigation.

Three syndactylous animals were recorded which were unrelated to the polydactylous group.

III. *Hydrocephalus*

Hydrocephalus is a condition caused by the accumulation of cerebrospinal fluid in the third ventricle of the brain. This accumulation is due in some cases to an obstruction of the aqueduct of Sylvius which connects the third and fourth ventricles. Hydrocephalus is found frequently in several species of animals, and in the mouse it has a hereditary basis. There are three types of hydrocephalus in the mouse, and all are recessive in inheritance. The animals usually have a more or less dome-shaped skull. Hy-1 animals may be recognized at birth or within the first 15 days after birth. Mortality is high between 20 and 40 days, but a few may reach sexual maturity and breed. Hy-2 mice do not breed and must be derived from heterozygotes. Growth is retarded and the animals seldom reach normal size. Hy-3 is not usually recog-



SURVIVAL AND GROWTH
Figure 10

Curves of survival (*A*) and of growth in grams (*B*) for mice in the hydrocephalic strain. Mice in litters where all were normal showed slightly better performance than did normal mice in litters having hydrocephalic individuals. Males and females are combined in these curves.

nized until the second week or later. Severely affected animals are retarded in growth and rarely reach two months of age, whereas mildly affected individuals may reach maturity. A nasal discharge is commonly present and the skull is characteristically dome-shaped, but is variable in degree.

In the mouse colony maintained by the Bureau of Animal Industry several hydrocephalic mice have been produced, mostly in matings of close relationship. These were distributed between strains S, B, a^t, CdE, and Cin. The last two are crossbred strains and are related. The affected animals had the characteristic dome-shaped skull. In most cases they failed to grow at the same rate as their normal litter mates and mortality was very high. More than twice as many females as males were affected (13 males, 30 females). Most of the matings which produced hydrocephalic mice also produced entirely normal litters. In only six litters of the 33 which produced hydrocephalic mice was more than one animal affected. Considering only those which were alive at 15 days, the percentage of hydrocephalic mice was 12.95. It is difficult to classify the individuals born dead or which died prior to 15 days. The percentages are shown in Table I for those born dead or which died between different ages.*

The percentage dying between any two ages was calculated on the number alive at the first age mentioned. Figure 10*A* shows the mortality expressed as the percentage of those born alive at a particular age. In calculating the growth curves shown in Figure 10*B* males and females have been combined.

The results observed in our stock resembled quite closely those reported by others working with hydrocephaly in mice. The defect appears to be recessive in inheritance. Whether it represents hy-1 or hy-2 has not been determined, partly because of the small number of hydrocephalic mice involved and partly because matings were not made to study its heredity. Only one mating was made in which a parent (the mother in this case) was hydrocephalic. She produced one litter of seven normal mice. This would suggest that the strains to which she belonged (S and CdE) were hy-1, since hy-2 mice do not breed. The period of highest mortality was between 60 and 90 days which is later than reported by Clark.[9] Clark considered the deficiency of recessives due to selective elimination prior to the age of classification. If those born dead and those dying between birth and 15 days are considered as hydrocephalic and added to those which were reported as hydrocephalic, the departure of recessives from a 3:1 ratio is not significant. However, it could hardly be expected that all deaths prior to 15 days in the litters considered would be due to hydrocephalus. There were, however, 13 animals which were not classified as hydrocephalic which well might have been. Their weight was several grams less than that of their litter mates at a given age. Two of them died before reaching maturity (one between 30 and 45 days, and one between 60 and 90 days). Of these 13 animals seven were in litters which produced hydrocephalic mice. The others were in litters recorded as having produced only normals.

The weights of normal mice in litters which produced hydrocephalic mice and those which produced only normals did not differ significantly except at 120 days. Weights of normals differed significantly from the weights of hydrocephalic mice at all ages beyond 15 days.

Size of litters in those producing only normal mice did not differ significantly from size of litters in which hydrocephalic mice were born. Thus there was no apparent prenatal mortality due to the defect. One-half of the hydrocephalic mice born alive were dead at 67 days, whereas about 90 percent of the normals were alive at this age.

It is possible that some of the mice were hy-2, although there is no proof of this. Accurate records were not kept as to the age at which the defect was first observed in the various individuals, but notes on the litter sheet indicate that some were observed at the 15-day

*The Tables referred to in this section on Hydrocephalus will be found in Supplementary Document No. 3699.

weight while others were not recorded as hydrocephalic until the 60-day weight. Possibly some were not visibly hydrocephalic even at 120 days, as might be indicated by their slow growth and weight at different ages. This could also account for a deficiency of recessives as reported by other investigators.

Summary and Conclusions

Account is given of hydrocephalic mice occurring among several strains in the Bureau of Animal Industry stock. Two of the strains (CdE and Cin) were related. The others were unrelated.

Approximately one-eighth (12.95 percent) of the mice born in various matings were hydrocephalic. There was an excess of females affected.

Size of litters producing only normal mice did not differ significantly from those producing both normal and hydrocephalic mice.

Weight of normals in both kinds of litters did not differ significantly except at 120 days, but differed significantly from weights of hydrocephalic mice at all ages except 15 days.

Mortality of normal young in litters producing hydrocephalic mice was slightly greater than in litters producing only normal young. Mortality of hydrocephalic mice was much greater than among normal litter mates.

Some of the hydrocephalic mice were apparently hy-1.

Literature Cited

1. Bagg, H. J. *Internat. Clinics* 4:26-33. 1926.
2. ————. *Am. Jour. Anat.* 43:167-219. 1929.
3. Bonnevie, K. *Skr. Norske Videnskab.-Akad. Oslo*, 1930, No. 13, pp. 26. 1931.
4. ————. *Zeitschr. Ind. Abstamm. u. Verb.* 62:73-84. 1932.
5. ————. *Jour. Exp. Zool.* 67:443-520. 1934.
6. Caspari, E. and P. R. David. *Jour. Hered.* 31:427-431. 1940.
7. Chang, T. *Peking Nat. His. Bull.* 14: 119-132. 1939.
8. Clark, F. H. *Proc. Nat. Acad. Sci.* 18: 654-656. 1932.
9. ————. *Anat. Rec.* 58:225-233. 1934.
10. Crew, F. A. E. and C. Auerbach. *Jour. Genet.* 41:267-274. 1941.
11. Dobrovolskaia-Zavadskaia, N., *C. R. Soc. Biol.* Paris. 97:114-116. 1927.
12. ———— and N. Kobozieff, *C. R. Soc. Biol.* Paris. 109:346-348. 1932.
13. Dunn, L. C. and S. Gluecksohn-Schoenheimer. *Genetics* 23:146-147. 1938.
14. ————, ———— and V. Bryson. *Jour. Hered.* 31:343-348. 1940.
15. Fortuyn, A. B. D. *Genetics* 21:97-108 1939.
16. Gruneberg, H. Genetics of the Mouse. Cambridge Univ. Press. 1943.
17. ————. *Jour. Genet.* 45:22-28. 1943.
18. Hunt, H. R. and D. Permar. *Anat. Rec.* 41:117. 1928.
18. Landauer, W. *Genetics* 33:135-155. 1948.
20. Lang, A. *Zeit. Ind. Abstam. und Vererb.* 8:233-283. 1912.
21. Murry, J. M. *Science* 75:312. 1932.
22. Reed, S. C. *Genetics* 22:1-13. 1937.
23. Roscoe B. Jackson Memorial Laboratory Staff. *Jour. Hered.* 36:271-273. 1945.
24. Strong, L. C. *Anat. Rec.* 58:88 (Abstr.) 1934.
25. Wright, S. *Genetics* 19:506-536. 1934.
26. ————. *Genetics* 19:537-551. 1934.
27. ————. *Genetics* 20:84-107. 1935.
28. Zimmerman, K. *Zeit. Ind. Abstamm. u. Vererb.* 64:176-180. 1933.

(Revised manuscript received March 24, 1952)

◆

ONR Seeks Biologist

THE Pasadena office of the Office of Naval Research announces that the position of Scientific Research Coordinator (Biology) is available. The duties of the position are to provide liaison with various ONR contractors in Southern California, Arizona and New Mexico, and assist in the coordination of government sponsored research in this area. Occasional opportunities arise to contribute to projects of national or international importance.

Working as a member of a team (Physics, Chemistry, Mathematics, Biology) it will be necessary to evaluate specific research proposals and to develop and maintain an intimate and critical knowledge of the research in progress at the various laboratories and maintain professional standing in the field of specialty.

An established reputation in biological and psychological research, with a specialty in one or more of the following fields is required: Physiology, Neurophysiology, Psychology, Experimental Psychology, and general Experimental Biology.

The position carries a salary of $8,360 per annum. Inquiries should be addressed to Director, Office of Naval Research Branch Office, 1030 East Green Street, Pasadena 1, California.

MAMMALIAN CHROMOSOMES IN VITRO

I. The Karyotype of Man

T. C. Hsu*

Tissue Culture Laboratory, University of Texas, Medical Branch, Galveston

THE following paragraph, quoted from Fischer[1], well states some of the advantages of studying chromosomes in tissue culture:

> Cultures present extremely favourable conditions for an investigation of the cell division. Entirely apart from the fact that the tissue culture offers a good general view of the individual phases of the division, it has the great advantage over histological section preparation that nothing is lost, something that may well happen in the case of the latter when first the microtome knife has cut the tissue. Another advantage of the tissue culture is that the growth zone often is but a single layer in thickness and therefore presents the best conditions for direct observation, photography or cinematographic recording.

Besides these the fixation of tissue cultures is direct and instant. In section or smear preparations, no matter how skillful the operation, a minute or two may be lost during dissection thus causing some undesirable effects, such as clumping of chromosomes. The fixatives are more effective because their penetrating power is enhanced due to the thin sheets of outgrowth in tissue culture.

One of the earliest workers on human chromosomes *in vitro*, Kemp[3,4], used tissue cultures of embryonic heart, liver and spleen and made some important inroads with this technique. Unfortunately, this approach has been almost completely neglected by cytologists.

Materials and Methods

Cultures of embryonic skin and spleen were made from a four month old male fetus. The tissues were cut into square pieces, approximately 2 mm. on each side for the skin and 1 mm. on each side for the spleen. Each explant was mounted on a ⅞" square cover slip in a clot composed of equal parts of extract from seven-day chick embryos and heparinized cockerel plasma and sealed with paraffin on a depression slide. The skin cultures received approximately 0.05 ml. of malignant human ascitic fluid as a liquid nutrient but nothing was added to the clots of the spleen cultures. After five days of incubation at 37°C., the skin cultures were fixed in pure methyl alcohol and the spleen cultures in Helly Zenker's. The skin cultures were stained in a combination stain consisting of May-Greenwald and Giemsa, known as Jacobson's method, while the spleen cultures were stained with hematoxylin-eosin-azure.

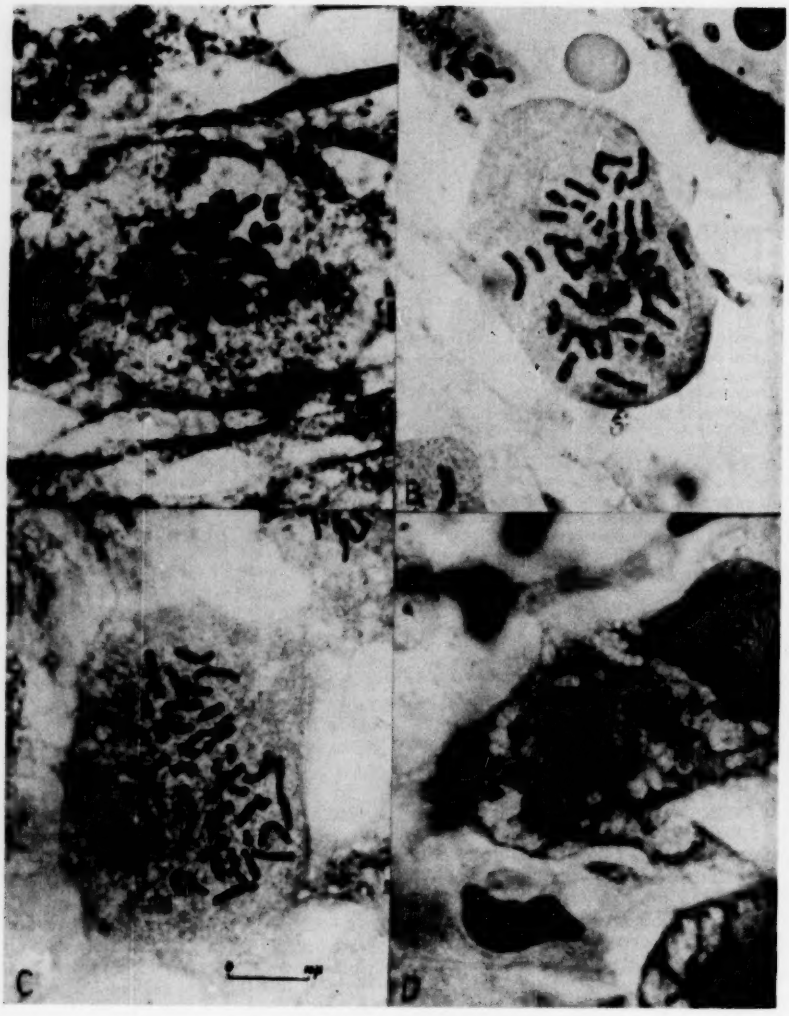
Results

The elements in the zone of outgrowth of the skin cultures were mainly epidermal cells and fibroblasts. Unlike the epidermal cells in cultures of adult skin in which there is very little mitotic activity (Hsu[2]), embryonic epidermal cells showed some regular mitotic figures, while fibroblasts exhibited considerably more mitotic activity. Figure 11*A* shows such a fibroblast at metaphase.

In these cells various degrees of overspiralization of chromosomes were observed and many cells contained small, compact chromosomes which made the karyotypic study difficult. Anaphasic movement was remarkably normal, with no evidence of abnormalities. Counts were made only in four cells in which all were shown to contain 48 chromosomes.

For the purpose of karyological studies, the spleen cultures were more desirable because their chromosomes at prometaphase were very well outlined and much better dispersed. Figures 11*B* to 12*D*

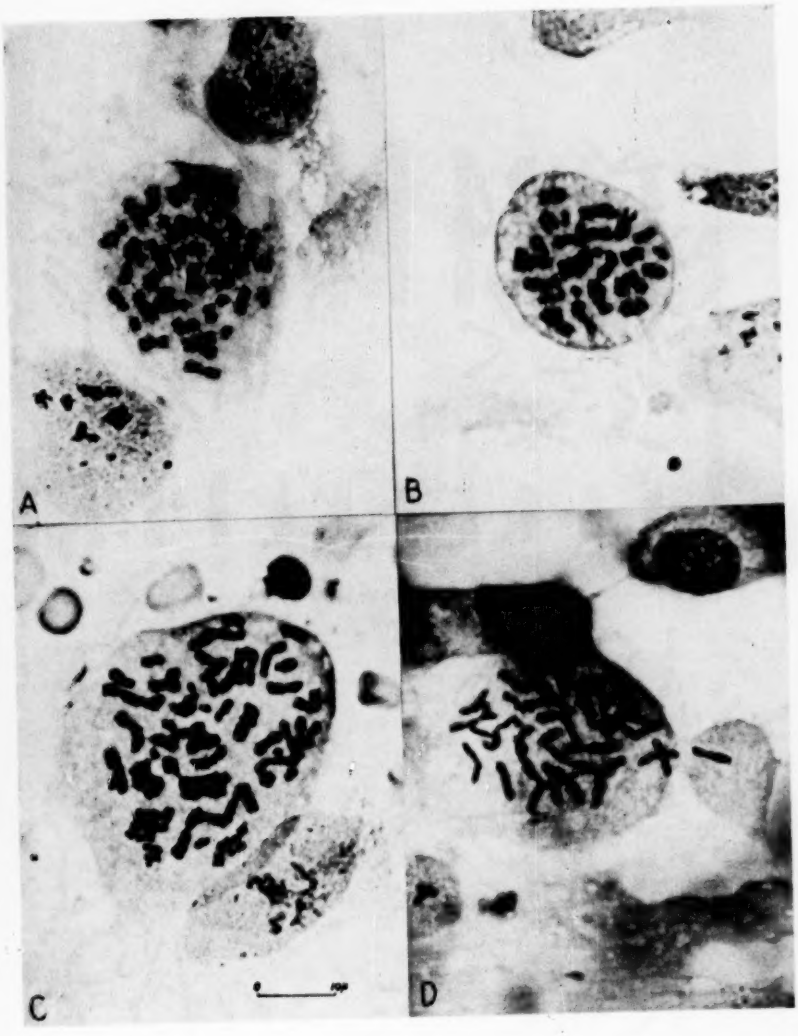
*Damon Runyon fellow: aided by a grant from the American Cancer Society (CP-12D) administered by C. M. Pomerat. Grateful acknowledgement is made to Mmes. Mildred Finerty, Helen Dunton and Patricia Johnson for indispensable assistance with the preparation and staining of the cultures. I am also indebted to Mr. George Lefeber for his help in preparation of the photographs.



HUMAN CHROMOSOMES

Figure 11

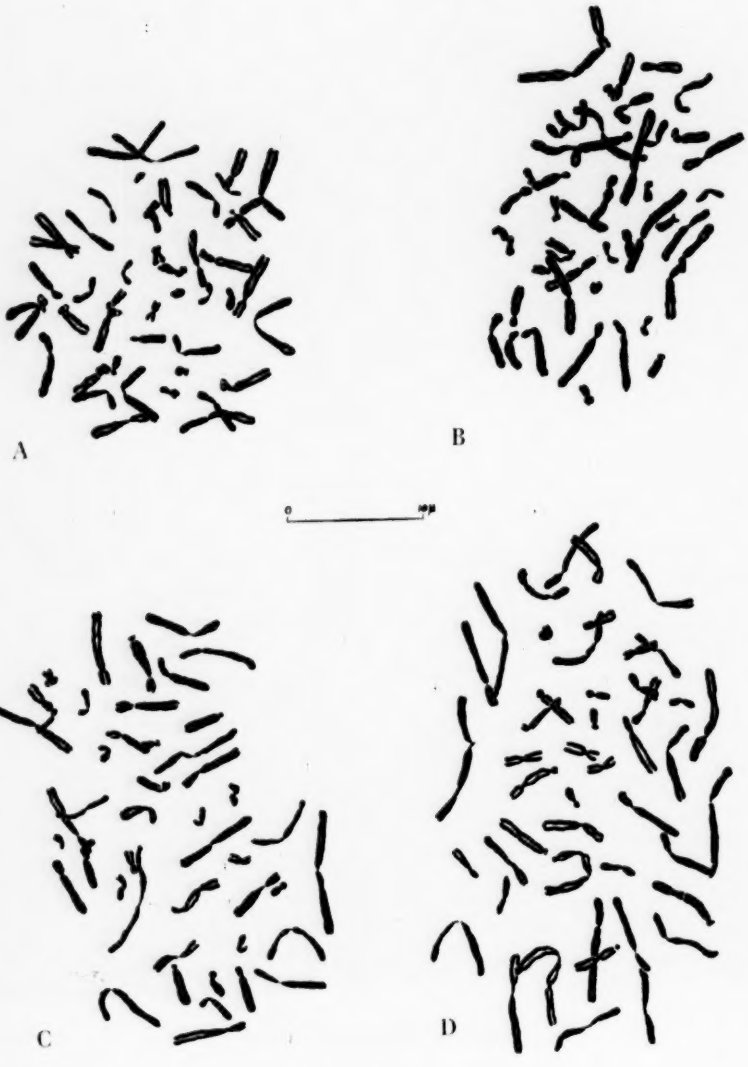
Figures 11 to 13 present cells from a four month human fetus cultivated *in vitro* for five days. *A*—A cell from a skin explant, presumably of fibroblastic type, showing marked over-condensation of chromosomes. Fixed in methyl alcohol stained according to Jacobson's method. *B-D*—Cells from splenic explants believed to be fibroblasts. Fixed in Helly Zenker's followed by staining with hematoxylin-eosin-azure.



EMBRYONIC SPLEEN CELLS

Figure 12

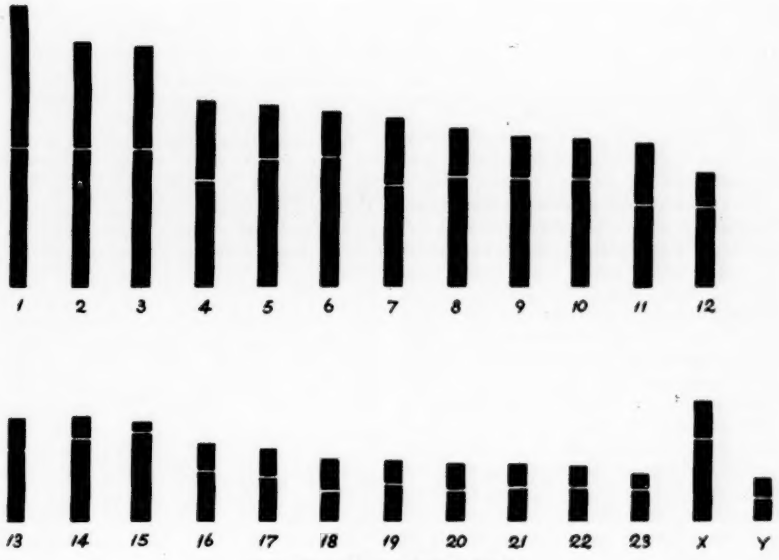
Cells from splenic explants. From the same source as the tissue illustrated in Figure 11.



CHROMOSOME CONFIGURATIONS

Figure 13

Camera lucida drawings of cells of the type represented in Figures 11 and 12.



THE HUMAN CHROMOSOMES

Figure 14

Diagrammatic representation of the haploid set of human chromosomes including the sex pair as seen in preparations of human embryonic spleen cultivated for five days *in vitro*. The autosomes are numbered according to their length, regardless of the position of the centromeres.

represent selected examples of splenic elements. In these cells not only can the numbers of the chromosomes be critically counted, but also their relative length and the position of the centromeres can be studied in detail.

In her work on bone marrow, La Cour[5] reports that there is a difference in the charge of nucleic acid between promyelocytes and proerythroblasts. In promyelocytes the chromosomes are long and thin, relatively undercharged with DNA and hollow spindles are usually formed at metaphase. In proerythroblasts the chromosomes are over-spiralized, heavily charged with DNA and the metaphase plates are mostly multipolar. In the spleen cultures, although most cells in division stages probably were fibroblasts, many exhibited long and thin chromosomes and some behaved as if they were in C-mitosis. A few metaphases also showed hollow spindles.

Figure 13*A* is a typical example of the C-mitotic cell, in which all the chromosomes had their chromatids widely split except the centromeres. Figure 13*B* represents an early anaphase in which the centromeres are also separate but there is no sign of moving to the poles. Apparently such cells form tetraploids.

Counts were made of 124 cells from the spleen cultures among which 91 or approximately 73.4 percent were shown to contain 48 chromosomes. One cell was probably a hypotetraploid, showing 91 chromosomes (Figure 13*C*). The rest of the cells had chromosome numbers as follows: four cells with 49 chromosomes, 11 cells with 47, 11 cells with 46, five cells with 45 and one cell with 44. Obviously polyploid cells were not common in the tissue before it was cultured.

More than 70 anaphases and early telophases were examined but no visible abnormalities, such as lagging, bridge formation, uni- or multipolarization, were noticed. No micronuclei were observed in either the skin or the spleen cultures. The most probable cause of the deviation of the diploid chromosome number would thus be non-disjunction, but it is extremely difficult to obtain accurate direct counts from anaphases. Another possible way

of eliminating a chromosome from a set is shown in Figure 12*D*, where a single chromosome is cut out from the main cell at metaphase. This phenomenon was encountered twice in the series. Presumably the fraction of cytoplasm containing one or two chromosomes cannot survive.

The morphology of the chromosomes has been studied to determine the karyotype of man.

A diagrammatic representation of the haploid set of human chromosomes, including the sex pair, is shown in Figure 14. The autosomes are numbered according to their length regardless of the position of the centromeres. There are no true telocentric chromosomes, every chromosome has two definitive arms. The lengths of the chromosomes when lined up form a graded series without a sharp break between long and short members. The longest is a pair of V-shaped autosomes with the two arms nearly equal in length. Most chromosomes are J-shaped, and pair number 15 has the shortest second arm, almost in the form of a knob. The only way to determine the sex pair is by matching the chromosomes in pairs. In the matching of chromosomes in human spermatogonial mitosis, Painter's[6] result showed that the *X* is a medium-sized chromosome, but in La Cour's[5] drawing the *X* appears to be a rather long J. In our material two unmatched chromosomes, one a medium-sized J and the other the smallest chromosome, are presumably the *X* and the *Y* respectively.

Addendum. It was found after this article had been sent to press that the well-spread metaphases and the seemingly C-mitotic anaphases were the results of an accident. Instead of being washed in isotonic saline, the cultures had been washed in hypotonic Tyrode solution before fixation. Furthermore, it was found that Dr. Arthur Hughes of the Strangeways Research Laboratory, Cambridge, England, had been carrying on experiments on the effect of hypotonicity upon dividing cells and his findings were almost identical with ours. We owe our sincere thanks to Dr. Hughes for allowing us to read his original manuscript prior to its publication.

T. C. H.

Literature Cited

1. Fischer, A. Biology of Tissue Cells. Camb. U. Press, 1946.
2. Hsu, T. C. *Texas Rep. Biol. and Med.* 10:336. 1952.
3. Kemp, T. *Zeit. Anat. Forsch.*, 16:1. 1929.
4. Kemp, T. *Zeit Zellsf. Mik. Anat.*, 11: 429. 1930.
5. La Cour, L. F. *Proc. Roy. Soc. Edinb.*, B, 62:73. 1944.
6. Painter, T. S. *Journ. Exp. Zool.*, 37: 291. 1923.

(Received March 10, 1952)

* * *

AMERICAN TOMATO YEARBOOK

THE 1952 edition of the *AMERICAN TOMATO YEARBOOK* has just come off the press. It is again edited by Dr. John W. Carncross, Rutgers University College of Agriculture, and contains much information for the tomato grower, the tomato dealer and shipper, the tomato canner, and the tomato research specialist.

The main function of the Tomato Genetics Cooperative at present is to compile and to distribute to members a Report issued annually that embraces the following parts:

Part I Research Notes. This part, consisting of short articles relating to tomato genetics is probably the most useful section of the report. Part II. Directory of Members. Part III. List of Available or Desired Stocks. Part IV. Bibliography of papers on tomato genetics and breeding published during the preceding year. Part V. Financial Statement.

The book is profusely illustrated with up-to-date charts and graphs giving a complete picture of the tomato industry. In addition there is much statistical information of vital importance. This includes a tabulation of states giving current data on tomato yield, acreage and production for both processing and fresh market, statistics on tomato juice, tomato pulp, tomato catsup, tomato imports and exports.

The requirements for membership in the Tomato Genetics Cooperative are an active interest in the work and willingness to pay the annual assessment. Anyone interested in joining or in securing additional information should communicate with Dr. John W. Carncross, Rutgers University, New Brunswick, N. J. Comment on any aspect of the activities of the Tomato Genetics Cooperative is always welcome.

BALANCING POPULATION AND RESOURCES

The Greatest Challenge of Social Engineering*

MAX ADAMS†

IN 1945 there appeared a small book entitled, "Population Roads to Peace or War," by Guy Irving Burch and Elmer Pendell. That short volume set forth the population challenge concisely. It was not the first recent volume to point out that increasing international tensions may have a close relationship to population pressures. It is nevertheless a useful anchor point, for it was the first of a number of post-war books and articles intended to persuade people to the point of view that both individual and social action will be required if mankind is to control his numbers so as to live in peace with a reasonable standard of living.

Since 1945 many thoughtful and some eminent people have affirmed and elaborated upon the theme which Messrs. Burch and Pendell set forth. In his first Presidential Report as President of the Rockefeller Foundation, Chester Barnard listed the major challenges confronting mankind, and at the top of the list was that of population planning in relation to the earth's resources. Later in the same year, William Vogt published his "Road to Survival" which had wide circulation and awoke more people to the seriousness of the problems we face. In 1950 Julian Huxley predicted that the 20th century would in the eventual future become known not for its wars or for the discovery of how to unleash the energy of the atom, but as the century in which mankind for the first time took stock of himself and recognized the need for steps to control population growth in order to bring people and resources into some degree of balance. In 1951 Robert Cook published "Human Fertility—The Modern Dilemma," stressing in popular terms the quality problem as well as the quantity problem, and the interrelationship of the two. The six years since the end of the war have been years of awakening.

Yet despite this awakening (and there are, of course, a great many more examples of it), there has been very slow progress in social action or even in suggestions as to types of social action which should be taken to meet the problems enumerated in the above-mentioned books. Indeed, with due respect for the high educational value of the books by Mr. Vogt, Mr. Cook and others, they alarm people without providing them with an understandable and feasible program for combatting the source of their fears. This leads to acute frustration, with which the world is more than adequately supplied. The *Population Bulletin*, published by the Population Reference Bureau quoted in its June 1951 issue a number of excerpts from letters written by alert but frustrated people. At the conclusion of the quotations the *Population Bulletin* editorializes, "The Bureau has long been a clearing house for population information. But the recurring questions: 'What agencies are doing something about this problem?' and 'How can I help—how can I put my shoulder to the wheel?'—these are a new development. This is a good omen. For the recognition that a need exists must precede intelligent action. The tragedy is that answers to these two re-

*As used in this paper, the term "social engineering" is intended to mean full use of known channels and techniques of education and of social and political action to solve major social problems.

†Max Adams is a pseudonym for a government official who regards it necessary to remain anonymous.

peated questions must still be in the negative and indefinite. No national or international organization is at present devoting any serious consideration to even pilot experiments to develop ways that might afford direct action to balance births and deaths. Obviously, no avenues exist at present whereby these people can channel their efforts toward a solution of the problem of overpopulation. . ."

Need for Social Programs

The demographers, the geneticists, the ecologists, and the nutritionists, all of whom are in short supply, have their hands more than full in building up knowledge in their respective technical fields. Most of them have neither the time nor the temperament for developing social action programs "whereby these people can channel their efforts toward a solution of the problem of overpopulation." The recent appointment of William Vogt to the national directorship of Planned Parenthood and his initial steps to enlarge the scope of and support for that organization is a noteworthy exception to this generalization. There are other exceptions, too, but they are few enough to "prove the rule." Organizing, nationally and internationally for population planning is a job which demands, in addition to scientists, journalists, and devoted members of organizations like Planned Parenthood, what might be called, for want of a better term, social engineers. It requires people who are equipped to design and construct social action programs. We need to construct a long highway with a series of bridges to our ultimate destination. The choice of precise route, the type of construction and the design of bridges remains yet to be determined. But the general direction in which we must travel is clear, and the fact that we must build a road to take us "over the hump to China," as the Burma Road did, is certain. Unfortunately, we are short of good engineers—social engineers.

Guy Irving Burch and Elmer Pendell put most of their faith—if one may judge from their book—in the United Nations as the social instrument to solve our problems. It was to be our road to population planning. Though the United Nations is making a number of very notable contributions in this field, it is difficult to see how any one with a deep understanding of the processes of democratic government at the national and international levels would invest so much faith in any governmental body for the solution of population problems during the middle of the twentieth century. Burch and Pendell thought it realistic to suppose that the United Nations could insist that occupied nations adopt a vigorous program of population planning which would help such nations as Japan to bring births into relative balance with deaths. The action of the opponents of contraception, both in the United States and on the staff of General MacArthur, and the impotence of the few unorganized voices which were raised in protest, brought out clearly how quickly and easily rational action may be upset by dogma when the former is supported by a few intellectuals and the latter by a highly organized and powerful minority. Realistic social engineering would take account of such factors. To influence social policy in democratic nations, and specifically in this nation, it is essential to develop and use techniques of social influence which are suited to the end in view. Careful planning and organization will be required. The task is enormous, but we dare not back away from it.

If we are to meet the challenge before us we must consciously develop realistic and somewhere nearly adequate plans to overcome the difficulties which can clearly be foreseen. Drawing such plans is not a quick and simple task, especially in view of the fact that social engineers specializing in population and resources are virtually non-existent. As previously mentioned, Mr. Vogt, the new national director of Planned Parenthood may develop into an outstanding one, having moved from a scientific background into leadership of a major private organization dedicated to the development of rational population policies. Though Planned Parenthood does not now have a comprehensive plan for the development of adequate population policies, nationally and internationally, it has the potentiality of producing one, and in the process, of developing a good training ground for social engineers. The Conservation Foundation in New York is also a hopeful training ground for such engineers, but it, too, seems more timid in its preliminary planning than the urgency of the situation warrants. Bold plans are required, both to capture the imagination and support of millions of people to whom lesser plans would seem futile, and to meet the challenge in a realistic way.

The remainder of this paper is an effort to suggest ways in which broader plans for social action to balance population and resources might be developed.

I. Clarification of Objectives

What are the real objectives of those of us who are concerned about bringing population and resources into balance? This broad definition may be useful: Our objective is to increase the standard of living, the level of health, and the quality of life of the families and of the peoples of the earth, and thus to reduce international tensions and promote peace. There are many means to that end. Limiting population growth is but one and must be kept in that framework.

Population is one of the two elements in the population-resources equation. Those who are concerned about population must align them-

selves with and work particularly closely with those who work upon the resources element of the equation. Otherwise the very purpose of limiting population growth loses its proper setting and perspective.

It is very easy for zealots to become so enthusiastic about a particular means toward an end that they think of their remedy as being the only means toward the end, or even an end in itself. This can easily happen in the population field. It would be unfortunate, for example, and might alienate much potential interest and support if those who are concerned with slowing down population growth were to convey the impression that there is anything *inherently* better about a family of three than a family of six. It is very easy to fall into this fallacy of confusing means and ends. It must be avoided.

This matter of objectives is more important than appears at first glance, since the rapidity of public understanding and acceptance is directly related to (a) concurrence in the major objectives *before* the means is accepted as necessary or desirable, and (b) willingness, *because of concurrence upon the objectives*, to be open minded on the subject of why it is wise to apply a heretofore unapproved or unrecognized method of reaching that objective. While this is elemental to salesmen of vacuum cleaners and other products, in the marketplace of ideas the principles of salesmanship are frequently not given their just due.

Beginning with the objective of increasing the standard of living, the level of health, and the quality of life of the families and of the peoples of the earth, it is usually possible to find common ground with most men and women of all races and creeds. From this starting point it is both possible and necessary to proceed in many different ways to demonstrate that human planning to help balance population and resources is one of the most important and even one of the most feasible means toward that objective. Millions of educated people in this country and in other countries do not realize that all signs point to the possibility of sound and sensible population limitation through providing the families and the peoples of the earth with the essential education, the motivation and the opportunity to plan their families as they wish. This is not intended as an oversimplification of an enormously difficult world-wide problem; it is intended to point out that great numbers of otherwise educated people regard it as either an impossible problem or else as a problem which might have to be solved through some form of governmental control which would be totally unacceptable. Still a third attitude—and this is probably more widespread than any other—is that the potential resources of the earth are so vast that if the efforts of mankind are concentrated upon the development and exploitation of those resources there will be no population problem. Therefore, as is indicated more fully in the balance of this paper, the challenge before those who are convinced that limiting population growth should be one of the major concerns of mankind involves not only educating those with limited education, but it also involves—and this is the very foundation of all future work in the population field—conveying a basic understanding of the population problem and its possible solutions to the millions of "otherwise educated" people whose support is required before major progress is possible.

II. Basic Methods

What are the basic methods by which these objectives can be approached? There appear to be at least four major methods: planning, research, education and social action. Each deserves much more extensive analysis and treatment than the sketchy comments below.

Planning

The "planning" which is referred to here is the initial and one of the most important phases of the "social engineering" mentioned above. It encompasses the broad planning to see that methods and organization to accomplish agreed-upon objectives are sound and reasonably adequate. The unavoidable criticism of most planning now going on in this field is that it is clearly inadequate in scope to have any prospect of meeting the intensifying population crisis within the foreseeable future. If the planning is too small and timid, the execution of those plans, even if flawless, will avail little. If balancing population and resources is one of the important challenges of all mankind in any century, then the plans to meet that challenge must be on a bold scale.

Planning should embrace the areas of research, education, and social action and should be both comprehensive and specific. As the architectural engineer starts by drawing initial large scale plans covering an entire project and subsequently produces detailed working drawings of each segment, so, too, must social engineering proceed to make plans on a large scale for a large undertaking and then proceed to develop detailed working plans for the various parts. Such planning will be extensive, covering many years, but it must be very consciously and carefully undertaken as a separate activity from research, education and social action. Some suggestions about the ways in which such planning may be approached and focused are indicated below.

The first key to success in this field of planning is good "staff work," geared in with imaginative leadership. The imaginative leader by himself, or with the aid of publicity men and operating assistants, hardly ever produces good plans. He gets bogged down in a combination of speeches, talking, reading, and operating details. He must have a small but very high quality *planning staff*. In respect to

a major human problem such as balancing population and resources a planning staff should, of course, possess broad knowledge of the basic scientific, demographic and sociological factors which form the backdrop of the problem. Even more important, however, is a deep and thorough understanding of the processes of education, social action, governmental operations (including practical politics) and the inter-relations of these in democratic countries. There are not now in existence enough people who have the right combination of training and experience to man the planning staffs which need to be created to cope with population and resources problems. Initially, they will have to be converted from related skills and backgrounds. Time does not permit a long period of training or retraining for the first group. But steps should be taken so that men and women with the right combination of training and experience will become available as rapidly as possible for this kind of work. Devising ways of accomplishing these objectives is part of the planning which needs to be done.

When such a planning staff or staffs have been assembled, they should very gradually begin drawing plans, keeping their eyes clearly focussed on the objectives and the magnitude of the task involved. They should consult with (not in single interviews, but through a series of interviews or discussions) the boldest thinkers available. Deeply penetrating questions should be put to those thinkers and they should be given time to ponder them and provide reflective answers, not off-the-cuff responses. Since such thinkers are scattered throughout the world, those who are not available for direct interview should be reached by mail. Their time and help should be carefully husbanded by giving them succinctly the benefit of initial thinking by the staff and asking them for the sharpest and severest criticism of it, both positive and negative. They should be urged particularly to consider the question of the adequacy of plans in relation to objectives sought. If they consider initial "sketch plans" inadequate they should be asked to make clear what the areas of inadequacy are and how they might be overcome.

In due course, the planning should be put on a broader base of participation. In this phase of the planning, education may be combined with planning; the planning is put to a broader test and the democratic process of review and compromise tends to make the eventual product broadly acceptable. Difficult policy questions will arise in trying to determine how far it may be necessary to compromise "sound planning" in order to gain a necessary degree of acceptability and support, financial and otherwise.

For several decades the decennial White House Conference on Children and Youth has been stimulating and nurturing broad interest and planning through a process which usually begins two or more years before the decennial conference and comes to focus in the large conference itself, the results of which are felt for many years afterwards. Lessons are to be learned from such techniques in the field of population planning. However, when the time is ripe for such a conference, national or international, in respect to population and resources, it should be under *private auspices*, though government officials might appropriately be invited. This point of private auspices is very important, since major topics of the conference *must*, if the conference is to be worth its salt, contemplate action which goes beyond anything which governmental officials would be in position officially to sanction. (This matter is discussed later under the heading of social action.)

The type of conference suggested here should result from the collaborative effort of a number of different organizations; it should not be the creature of, nor identified exclusively with, a single organization. Much planning would need to go into it, and a good, full-time staff would need to be available to it. It would be my suggestion that such a conference should be a world conference preceded by a series of regional and national meetings. Obviously, it would need to be scheduled far enough ahead so that a great deal of ground work could be accomplished before such a conference occurs. It should be broad enough in scope to make absolutely clear to the world that its purpose is not simply to whittle down the number of children born every year, but to seek ways of balancing resources and population, and through these means raise the standards of living and life so that mankind need not destroy himself violently and painfully.

Obviously, the suggestion of one or of periodic international conferences is not advanced as "the answer" to the need for planning in this field. It is an example of one important device that can and should be used more effectively than it has been used so far. Other methods and devices growing out of good staff planning will emerge. Some are suggested in the following sections on research, education and social action.

Research

Substantially increased knowledge is needed in demography, in ecology, in nutrition, in ways of increasing and improving the distribution of the world's food supply, and in simple and effective methods of birth control. Millions of reasonably educated people are skeptical about the dangers of any so-called "population explosion"; a greater and more persuasive body of data needs to be accumulated and presented in scientific form as the underlying base for any program of education and social action. The demographers, the ecologists, the

nutritionists, the conservationists, the agronomists, and the psychologists need to meet together more often than they have thus far in order to bring out more clearly the relation of their respective disciplines. The agronomists and agricultural experts need to set forth the range of their estimates as to the number of people the earth can support upon various assumptions, and they need the help of the nutritionists, the ecologists and the demographers to do so. The assumptions chosen need to be within the range of reasonableness, which is sometimes not the case when scientific specialists make predictions without checking the effects of related factors somewhat outside their immediate fields.

Research in the social sciences tends to be confined entirely too much to small projects which can be undertaken by one person or a very small group of people. More effort should be exerted in the direction of undertaking larger projects through the joint action of a number of universities or centers in different parts of this country and other countries of the world. This should become increasingly possible if and when more universities establish, as suggested under the heading of "Education," below, chairs of "Population and Resources," with research fellowships gathered around them.

Medical research, including particularly simpler methods of birth control, suitable in hot climates and for people with little education, is such an obvious need that it needs no elaboration.

Communication is an important problem in relation to research. A world clearing-house of information concerning projects contemplated, under way, and recently completed, with a good digest system, would make a real contribution.

The greater the body of knowledge, the more likely it is that mankind will come to grips with the problem of bringing population into balance with resources.

Education

There is obviously need for a tremendous educational job in respect to population and resources problems. Very large numbers of people, both educated and relatively uneducated, either think that no problem exists—that the world can easily support all the people that are likely to be produced in the next two or three centuries if the food and other essentials are properly distributed—or that the problem is so hopelessly difficult that it is unmanageable through conscious human planning and we will simply have to close our eyes and have faith in the Almighty. Obviously, great educational work needs to be done to overcome both of these attitudes and others. No superficial propaganda campaign will meet this type of need. An educational program covering several decades needs to be planned and launched. Some elements of such a program are suggested below:

1. *Building the educational foundation*
   a. Establish chairs of "Population and Resources" at as many universities and colleges as possible.
   b. At colleges and universities where it is temporarily impossible to establish such chairs, select key faculty members and bring them together into short conferences and institutes to hear the world's outstanding people talk about such problems.
   c. Prepare new college text material.
   d. Establish graduate fellowships in "Population and Resources."
   e. Establish an annual national undergraduate essay contest with a handsome award, on the subject: "What Concrete Steps Should be Taken by the Citizens of Democratic Nations to Help Bring Population and Resources into Balance?" or some variation thereof.
   f. Establish visiting professorships and visiting lecture series at various colleges and universities to alert the faculty and student body to the problems of population and resources facing our civilization.
2. *Books and magazine articles:* These will grow rapidly in number and volume as the basic educational foundation referred to above is built. Meanwhile, using to the fullest degree the potential interest of top-flight journalists and writers is absolutely essential.
3. *Pamphlets:* It is the function of social action organizations described below, to produce good pamphlets of various types. The development and effective use of good pamphlet material in this field deserves a great deal of attention, skill and effort. Pamphlet material should be designed in a non-argumentative way to answer the questions of the dubious. Such pamphlets must, for example, effectively refute these three previously mentioned fallacies which are commonly accepted by reasonably educated people: (a) that the earth, if properly cultivated, can support at least four billion people, and since we have only about 2,400,000,000 the main problem is not limiting the population but more and better food production on more of the earth's surface; (b) the combination of the sex instinct and the power of prejudice, ignorance and religious dogma make population limitation a hopeless matter to do anything about; and (c) Malthus tried to scare people 150 years ago into fearing dire consequences of population increase, and none of what he predicted has come true, though the population of the earth has tremendously increased since then, all of which makes him

obviously wrong, and the people who preach his warmed over gospel today are obviously equally wrong.

Pamphleteers whose business it is to sell ideas can learn many tricks and techniques from the advertising profession, but it would be a grave error to be guided primarily by those techniques. It should also be mentioned that far more work needs to be done on the effective use of pamphlets after they are produced.

4. *Television, movies and radio:* Good educational programs can certainly be worked out which can be used on television and radio and by the movies. Quantity is not nearly as important as quality. One good program may be worth ten mediocre ones; in fact, many mediocre ones may do more harm than good, on the "boy that cried wolf" principle.

There are several techniques whose worth has been proved in the rapid development and understanding of other areas of human knowledge previously hidden by clouds of ignorance and prejudice. Many of them are currently in use in respect to the field of "Mental Health," for example. There is the definite prospect that within our generation the clouds of ignorance and prejudice will be substantially removed from the field of "Mental Health." If such ignorance and prejudice can be dissipated in respect to mental illness, there is more than a hope that similar progress can be achieved in dealing with population and resources problems.

Social Action

Social action implies organization. The design of organizations which have pioneering missions to perform is very important, but frequently such organizations grow like Topsy with little thought given to their suitability to achieve their stated purposes. Some principles of design which seem to me to have a very direct and important bearing upon problems of population and resources are set forth below.

1. *Coordination without Unity*

First and foremost, the problems involved and the purposes to be sought are so very broad that no single organization can be soundly designed which will cover them all. What is needed is coordination but not unity. Trying to achieve unity under such circumstances is like trying to build a single 200,000 ton ship instead of a fleet of 2,000, 5,000, 10,000 and 20,000 ton ships. The creation of such a fleet of ships which will work together is a sound and feasible operation; the construction of a 200,000 ton ship is not. Yet if each of the smaller ships operates with complete independence rather than as part of a coordinated fleet, the combined mission of the individual ships may not be accomplished at all. Many organizations of different sizes and shapes are needed to work together for the broad purpose earlier stated: to increase the standard of living, the level of health and the quality of life of the families and of the peoples of the earth and thus to reduce international tensions and promote peace. Such a purpose may seem so broad that it is not even feasible for the various organizations which are working toward that end to act like a fleet and move forward together on a coordinated mission. It hasn't been tried. What I am suggesting is that there needs to be a World Congress on Population and Resources, under non-government auspices (for reasons stated below), to bring together and help coordinate the similar missions of the many different organizations which are working on the different aspects of this problem. Such a Congress would not be, in any sense of the word, an authoritarian body. But it would have great value in putting in perspective and giving tremendous impetus to the related missions of the member organizations.

Other advantages of coordination over unity are:

a. With many organizations working together toward a very broad purpose, there will not be a single target for the opposition to aim at. If groups who oppose tampering with the birth rate can concentrate their fire, it makes their job easier.

b. Many scientists and academic people do not like to belong to "missionary movements"; yet they are usually more than glad to participate effectively in spreading human understanding of social problems in ways which do not seem to reflect upon their objectivity; adequate provision should be made for the type of organization which will enlist the support of academic people and scientists.

c. Similarly, the "advance pioneers" may well be sufficiently ahead of "support pioneers," that it would retard public acceptance for two or more groups to pursue their objectives within the same organization. For example, it might well retard the "Planned Parenthood" movement (in its objective to gain world-wide acceptance of parental planning of conception), if the organization were to include in its program recommended policies in respect to sterilization of the unfit. It might well be preferable for advocates of those policies to form a separate organization, so that Planned Parenthood could move ahead more rapidly with its more attainable task of gaining acceptance of the principle that every normal married couple has the right to the knowledge and

the means whereby the couple can control the size of their family. Yet the work of both of these groups, plus many others, might be coordinated through a continuing World Congress on Population and Resources.

d. Philanthropic foundations often have limitations in their charters or in their policies which preclude their making any grants to particular kinds of organizations or for particular purposes. It may easily be possible, under such circumstances, to obtain funds from various foundations to contribute toward the solution of certain segments of the complex of problems involved, whereas those foundations would not or could not make such contributions to the solution of other segments or to efforts toward solution of the problems as a whole. To illustrate specifically, there are certain foundations which might well be interested in putting up funds to make major contributions in the educational field outlined above, if undertaken under proper auspices and in a sound manner, although they would be entirely estopped from making any grant to Planned Parenthood for research in improved methods of contraception, and would probably also be estopped from granting funds to Planned Parenthood for any purpose.

Devices and techniques other than organizational unity must also be employed. One of these is to develop close working relationships between the various organizations which are working on the problem, both formal and informal. One of the ways that is used by the American Political Science Association, the American Economic Association, the Industrial Relations Research Association, and others, is that of holding annual meetings in the same cities at the same time, with some joint and some separate sessions. Another technique of collaboration, formal and informal, is the kind of living and working together that is done by the various organizations which are housed together in the same building at 1313 E. 60th St., Chicago, i.e., the Public Administration Clearing House, the Public Administration Service, the American Municipal Association, the American Public Welfare Association, the Council of State Governments, etc. The advantages of being housed together are very great. If it were possible to develop physical centers in this country, as well as in other countries, which would be the focal points of the various national organizations which are laboring away at the business of trying to bring population into balance with resources, it would be a great boon to progress in this field.

2. *The Limitations of Government*

In social pioneering, such as population control, it is unwise and unsound to place undue reliance upon the possible achievements of governments and the international bodies created by governments. Valuable as may be the contribution of the United Nations and the related bodies of the World Health Organization and the Food and Agriculture Organization, these are bound to be hampered by the conservatism of member governments. The member governments, especially those of democratic countries, are, in turn restricted in their positions by the bodies politic, made up in great degree of articulate and competing minorities. Only to the extent that it is possible within each democracy to (a) organize a strong and articulate minority in favor of population planning, and (b) through that minority and through a solidly constructed educational program to leaven the attitude of the body politic, will it be possible for international bodies such as UN and its satellites, UNESCO, WHO and FAO to deal on a grand scale with population control problems. Reference has already been made to the unmistakable lesson which was taught by General MacArthur's over-ruling of initial attempts to gain governmental sanction for a wide-scale program of birth control in Japan. The report of the United Nations Mission of Technical Assistance to the Republic of Haiti in June 1949 provides another illustration of the conservatism of international bodies. Though this technical mission included representatives from the Food and Agriculture Organization, the International Monetary Fund, the United Nations Educational, Scientific and Cultural Organization, and the World Health Organization, and though the Mission considered the population problem sufficiently to be much concerned by it, they made only one brief recommendation: ". . . the Mission recommends that serious consideration be given to the possibility of emigration as a means of relieving the acute population pressure. . . ." Nothing whatever is said about slowing down the population increase.

Since governmental bodies—national and international—cannot be relied upon adequately to meet the challenge of population planning, a great deal of immediate emphasis needs to be put upon non-official international organization for this purpose, with strong supporting national affiliates. At least one organization, Planned Parenthood, is moving slowly in this direction. But the question that insists upon an answer is: Are the plans not too small and timid? Do not the circumstances call for a bolder design? Would not a bold design capture the

imagination and support of many to whom lesser plans seem futile? In social engineering, there is but one way to test a design and that is to place it before thinking people and observe its reception. A small social response to meet a great social problem represents, in part, at least, a design failure on the part of those who describe the challenge and the recommended manner of meeting that challenge.

3. *Partnership, not Paternalism*

Bluntly, the United States has most of the financial resources to do something about these problems but the most acute problems in respect to bringing population and resources into balance are in other sections of the world. How, then, shall we aid in educating and providing technical assistance in respect to population and resources problems to those sections of the world which need such education and technical assistance most? At least two alternatives are open. One is the "Point Four" technique. The other is the use of an international organization (one or more) for providing technical assistance to various countries in proportion to their need for and willingness to make use of the assistance. The "Point Four" technique has merit as a temporary expedient when no other alternative is workable, but it seems to me clear that it is not a sound plan when we are designing a social pattern which will endure. Other nations would not like to have the United States send funds and technicians to tell them how to hold down their population; it would seem like a kind of paternalistic meddling in their affairs unless they ask us to come. Even when they ask us, the feeling of asking for help from a rich uncle is there—obviously not a good psychological relationship. In the long run, the only sound relationship is one of partnership within one or more world organizations to which the various national organizations contribute and from which funds and technical assistance would be made available to member groups on the basis of need. Then the peoples of the earth would feel that they were cooperating to achieve a common purpose instead of receiving largesse from a wealthy uncle. International action must be based upon partnership, not paternalism.

4. *Some Other Observations about "Planned Parenthood"*

Following are a few suggestions which are directed primarily toward strengthening the organization of "Planned Parenthood." There is some applicability of these ideas in respect to other organizations as well.

a. When the purpose of an organization is to educate large numbers of people as rapidly as possible, its name is important. In the case of an organization like Planned Parenthood, the name contains no hint to the uninformed and unconvinced that here is an organization that is attempting to grapple with one of the most basic and important problems of humankind. There are hundreds of thousands of potential supporters of Planned Parenthood (and other organizations devoted to population and resources problems) who think of Planned Parenthood simply as a women's organization to help uneducated women learn about contraception. They do not regard that as a world-shaking matter worthy of their heavy financial support. Careful consideration should be given to the development of an alternative name which will reflect more fully the greatness and urgency of the mission upon which the organization is embarked. As an illustrative suggestion, one possibility might be: RACE FOR PEACE, Inc.

b. Closely related is the focus of the organization. I believe that if Planned Parenthood were to be placed in the perspective suggested in this paper that it would be possible and highly desirable to unstamp it as a women's organization and obtain the backing and support of both men and women who have the interest and imagination to understand the boon to mankind which will come from this movement as well as the personal help and improved health which so many mothers derive directly.

c. Consideration should be given to the development of an interesting quarterly publication direct from the national headquarters to every member of the organization, to help provide each member with a real sense of accomplishment, of stewardship, and, most important, of broad perspective. Such a publication would keep before the members an understanding of the relationship of the work of the organization to the objectives of raising the world's standard of living and reducing international tensions.

III. Concluding Observations

The preceding comments and suggestions are those of a government official who observes the crying need for action in this highly important field of population and resources and who is keenly conscious of how little is being done by government, particularly on the population side of the equation, or is likely to be done by government until there is a great groundswell of support to counteract the lack of understanding, the political apprehension and the caution possessed by elected and ap-

pointed officials. The fact that Mr. Nehru, as the official head of the government of India, is taking important forward steps should not make us overly optimistic about the prospect of progress through government. In India as much as anywhere there is need for building the basic structure of intellectual leadership and social support without which Mr. Nehru's efforts are likely to be both precarious and flimsy. In any event, the load of responsibility for providing the educational foundation in these vital matters should not be heaped upon government (including official international organizations). It is clearly the responsibility of intellectual leadership and non-governmental social-action leadership within our democratic nations to do the basic work of building the broad foundation of understanding and support upon which later governmental programs of various kinds can be based. I firmly believe that much greater support (of all types, including financial support) can be obtained for moving forward to meet mankind's greatest immediate challenge if the type of planning which is indicated here is adequately developed. Such plans should be laid before prospective supporters in such a way as to provide simultaneously an understanding of the acuteness of the need and the clear case that only through privately stimulated social action, with adequate non-governmental financial support can we move with a real prospect of success toward solution of these problems.

GOLDEN OATS*

DARRELL D. MOREY AND R. W. EARHART†

A FEW golden or yellow oat seedlings were found growing in a small plot of C. I. 5395‡ oats at Gainesville, Florida, in the fall of 1949. The golden plants were observed to grow and produce grain almost as well as normal green plants. The golden seedling factor apparently arose as a recent mutation in this selection.

C. I. 5395 is a reselection from C. I. 5208 oats parentage of which is Hancock-Morota-Bond × Fultex. Figure 15 shows the yellow seedlings in comparison with the green plants of normal oats.

In searching the literature to determine if similar yellow oats have been described previously, our attention was called to De Haan's[2] classification of chlorophyll deficiencies. According to De Haan, chlorophyll deficient plants can be classified as chlorina, xantha, lutescent or virescent. Chlorina seedlings vary from green through greenish-yellow, but continue to grow and reach maturity. Those classified as xantha are yellow and usually die as seedlings.

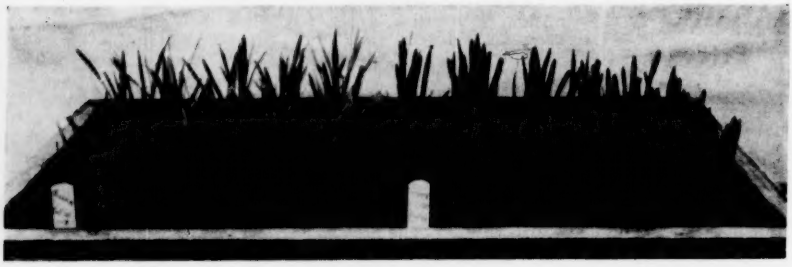
Lutescent seedlings start out as green seedlings, then the chlorophyll disappears and the plants die. Virescent seedlings start out yellow and turn green towards muturity. The yellow oat mutant under consideration here would probably be classified as a chlorina type according to De Haan.

Few yellow oat seedlings similar to this type have been reported. Akerman and Fröier,[1] in 1941, described a chlorina mutant found in Golden Rain oats in Sweden. Five years later Fröier[3] gave a detailed account of

*Contribution from the Departments of Agronomy and Plant Pathology, Florida Agricultural Experiment Stations, Gainesville, Florida, the Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Dept. of Agriculture. Florida Agricultural Experiment Station Journal Series, No. 75.

†Associate Agronomist, Florida Agricultural Experiment Stations, Gainesville, Florida, and Plant Pathologist, Division of Cereal Crops and Diseases, USDA, and Florida Agricultural Experiment Stations, Gainesville, respectively.

‡C. I. refers to accession number of the Division of Cereal Crops and Diseases.



GOLDEN OATS

Figure 15

Golden oat seedlings from C. I. 5395 (left), and normal green seedlings (right), 12 days after seeding.

the genetic ratios obtained when this chlorina mutant type was crossed with 28 other oat varieties from various sources. Crosses with Abeds Nova and several other Swedish oat varieties gave F_2 ratios of three green plants to one chlorina plant. Crosses with Victory and some other oat varieties from central Sweden gave ratios of 15:1. Crosses with *Avena byzantina*, *Avena sterilis* and other similar types gave a ratio of 63:1 in F_2, which indicated that three factors for chlorina were operating. Fröier considered that the expression of chlorina seedlings occurred only after successive mutations of homologous, polymeric genes giving rise to the ratios he reported for one, two and three factor pairs.

Observations and preliminary tests at Gainesville indicate that the golden character is similar in certain respects to the chlorina mutant found in Sweden. Golden plants have bred true for the yellow color through three successive years of observation. Golden oats have been crossed with two other varieties and in each case the golden color factor behaved as a simple recessive factor. Table I gives the results of a cross of golden × Minn. 0-200-10:*

Golden plants are yellow as seedlings. They may turn slightly greener towards maturity, but they never become completely green. Although the plants apparently lack chlorophyll, grain yields from the golden plants have been good. Both green and golden plants from C. I. 5395 oats are resistant to crown rust under field conditions and show considerable resistance to oat leaf spot, *Helminthosporium avenae* Eidam. They are susceptible to races 7 and 8 of oat stem rust in greenhouse tests. Golden selections with additional resistance to both crown and stem rust are in the process of being developed. In preliminary tests the golden character seems to be inherited independently of resistance to stem rust (race 8). Further genetic studies of the golden character are planned.

Golden oats have been found useful as a "marker" variety for separating experiments in the oats nursery. The golden character also could be used for testing natural crossing in oats. This method would be advantageous because the testing could be done in the seedling stage, eliminating the necessity of growing the plants to maturity. The golden character also should prove of value in testing genetic linkages in oats.

TABLE I. Observed and theoretical ratios of green and golden seedlings in the F_2 generation from the cross golden × Minn. 0-200-10.

	Number of Plants		
	Green	*Golden*	*Total*
Observed	130	40	170
Theoretical	128	42	170

Literature Cited

1. Akerman, A. and K. Fröier. *Hereditas* 27:371-404. 1941.

2. DeHaan, H. *Bibliographia Genetica* 10:357-412. 1933.

3. Fröier, Kåre. *Hereditas* 32:297-406. 1946.

*Minn. 0-200-10 is a selection from a cross of (Hajira-Joanette × Bond-Rainbow) × Santa Fe. Seed of this selection was obtained through the courtesy of H. K. Hayes, St. Paul, Minn.

(Received May 21, 1952)

THREE COINCIDENTAL CHANGES IN ATOM-BOMBED BARLEY

A Line of Barley with all Surviving Plants Heterozygous For an Interchange and a Gene for White Seedlings*

C. C. Moh and Luther Smith†

ORDINARILY, self-fertilization of a plant which is heterozygous for a chromosomal interchange gives rise to a population about 50 percent of which are like the parent, i.e., heterozygous for the interchange. Furthermore, in selfed populations 50 percent of the individuals are usually heterozygous and 25 percent are homozygous for a mutant gene. The present paper deals with a line of barley in which, in selfed progenies, 50 percent of the seedlings are white, and all of the green plants are heterozygous for a reciprocal translocation and for a mutant gene for the white seedlings.

Review of Literature

The behavior at meiotic metaphase I of chromosomes involved in reciprocal translocations has been reported to vary considerably from species to species. In maize the proportions of open and zigzag configurations are approximately equal.[2] In wheat (*Triticum monococcum* and *T. durum*) most of the figures are zigzag,[8] while in *Oenothera* open configurations are relatively rare.[1] In barley the degree of directed segregation seems to be intermediate between maize and wheat. According to Smith[4] (and unpublished observations of the senior author) about 60 percent of the pollen mother cells have zigzag arrangements of a quadrivalent.

Usually pollen and ovule sterility closely parallels the proportion of open configurations of the chromosomes involved in the interchange. For example, maize plants with a ring of four chromosomes are frequently referred to as "semi-steriles." In einkorn and durum wheat a ring of four chromosomes produces only 5 to 10 percent sterility. In barley, as would be expected, the sterility resulting from a reciprocal interchange is somewhat higher than that observed in wheat, i.e., about 25 to 30 percent on the average.[7]

Although an individual with a mutant gene usually gives rise to 25 percent of recessive individuals in selfed populations, Moh and Smith[3] have discussed several ways in which this normal ratio can be altered. These need not be repeated here, but certain of their postulates will be considered in the discussion to account for the observations reported in the present study.

Material and Methods

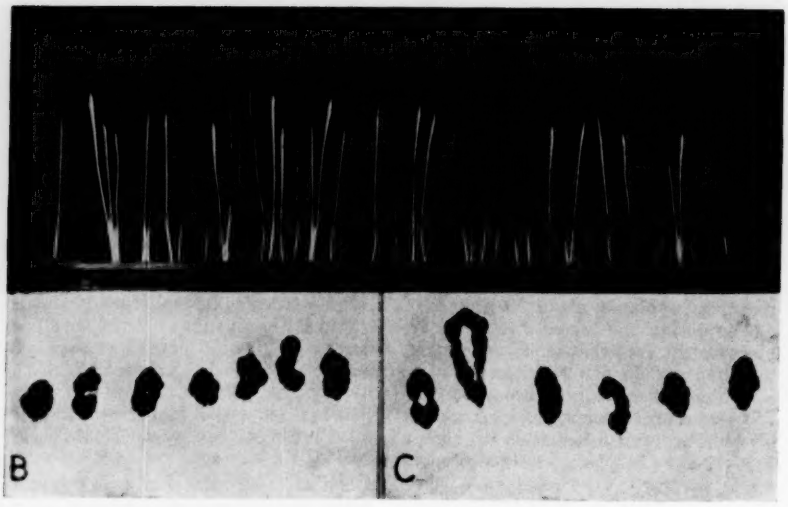
The mutant line dealt with in this paper was selected from a population of barley (var. Trebi, C. I. 936, 6-rowed) which was subjected to atomic radiations at Bikini in 1946.[6] The derivation of this particular line is briefly outlined in Table I.

The X_3 to X_5 generations were grown at Pullman, Washington. Progeny tests were made in the greenhouse by planting about 100 seeds from each plant in a row two feet long. The rows were two inches apart. When the first leaves were fully developed (about 12 cm. tall), the numbers of white and green seedlings were counted in each plant progeny.

Tests on germination were also conducted in the greenhouse in the same way. Since germination was practically normal, only seeds of the

*Scientific Paper No. 1075, Washington Agricultural Experiment Stations, Pullman. Project No. 1068. This study was supported in part by a grant from the Atomic Energy Commission. From a thesis to be submitted by the senior author to the Graduate School of the State College of Washington in partial fulfillment of the requirement of the degree of doctor of philosophy.

†Graduate student and late professor, respectively, Department of Agronomy, The State College of Washington. The authors wish to acknowledge the assistance of Mr. T. S. Osborne in making some of the crosses in this study.



WHITE BARLEY SEEDLINGS SHOW MEIOTIC IRREGULARITIES

Figure 16

A—Seedlings of the mutant line, showing the high proportion of white seedlings. *B*—Seven bivalents at the first meiotic metaphase of a normal plant of barley. *C*—Ring of four chromosomes plus five bivalents at the first meiotic metaphase of the mutant line.

X_4 generation were tested.

Crosses for testing the transmission of the mutant gene and the translocated chromosomes through male and female gametes were made with Compana, a normal 2-rowed variety. Since 2-rows are dominant to 6-rows in barley, false hybrids or self-contaminations were easily recognized and discarded. Tests of segregation in the F_1 hybrids were made by growing F_2 progenies in the greenhouse in the manner described above.

Acetocarmine smears (Smith[5]) were used for cytological examinations. The proportion of abortive pollen was determined by placing the mature pollen in an iodine-potassium iodide solution. (Stock: 0.3 gm. I_2; 1.5 gm. KI; 100 c.c. of 50 percent ethyl alcohol. Dilute 1:1 with HOH for use.) Ovule abortion was determined by finding the proportion of empty florets in the spikes.

Experimental Results

1. Cytogenetic Studies of the Mutant Line

a. Frequency of Transmission of the Mutant Gene.

As noted in the introduction, normally a recessive genic change gives rise to about 25 percent of mutants in selfed progenies, and two-thirds of the remaining individuals are heterozygous for the recessive gene. During three generations (1948-1951) of progeny tests on this mutant line, a total of 693 plants has been tested in the greenhouse. Every one of these 693 plants segregated for white seedlings.

The proportion of mutant white seedlings was unusually high. Every plant tested segregated more than 30 percent of white offspring. Of 66,208 X_3 to X_5 seedlings counted, 32,822, or 50 percent were white (Figure 16*A*).

b. Germination Tests.

Moh and Smith[3] considered a number of mechanisms by which the frequency of transmission of mutant genes could deviate from theoretical expectancies. One of these was the

TABLE I. Origin of the Mutant Line.

Year	Treatment	Generation*	Result
1946-1947	Seeds exposed to atomic bomb at Bikini; planted at Sacaton, Arizona.	X_1	Harvested the spikes from mature plants.
1947-1948	Studied the mutation frequency at Pullman, Washington.	X_2	Found a spike which gave 5 white among 21 seedlings.
1948-1949	Propagated this selected mutant and conducted progeny tests.	X_3	All plants tested were heterozygous and segregated a high proportion of mutant white seedlings.

*Plants grown from the bombed seeds are referred to as the X_1. Progenies of these plants are the X_2 generation; the next generation is the X_3, etc.

possibility that certain genotypes of seeds had low germinability. For that reason a germination test was made on 37 X_4 plants of the mutant line. From 3,090 seeds 2,947 (95 percent) seedlings emerged. Thus, the high proportion of white seedlings could not be due to poor germination of certain classes of seeds.

c. Cytological Observations on the Green Plants.

Cytological examinations were made on microsporogenesis in 51 X_5 and 34 X_6 plants. All 85 plants had a ring of four chromosomes at the first meiotic division (Table II and Figure 16C).

2. *Transmission of the Translocated Chromosomes and the Mutant Gene Through Male and Female Gametes*

Crosses by and on Compana were made to test the transmission of the translocated chromosomes through male and female gametes. It is obvious from Table II that the translocated chromosomes were transmitted by none of the male, and about half of the female gametes.

The transmission of the mutant gene for white seedlings was studied by F_1 progeny tests of the same crosses mentioned in the previous paragraph. The data are represented in Table III. It is apparent that all male and about half of the female gametes from the mutant line transmitted the mutated gene.

The percentage of white seedlings in these F_2 tests was also determined (Table III). The proportion of white seedlings (20 percent) segregated by the F_1 plants was distinctly lower than that segregated by plants of the parental line (50 percent).

TABLE II. Cytological Observations on the Transmission of the Translocated Chromosomes.

Source of plants	Plants examined cytologically Total No.	R_4 No.	7_{II} No.	Plants with R_4 %
Mutant line selfed	85*	85	0	100
Mutant line ♀ × Compana ♂ F_1	70	39	31	56
Compana ♀ × Mutant line ♂ F_1	43	0	43	0

*51 were X_5 and 34 were X_6 plants.

3. *Interrelationships of the Translocated Chromosomes, the Sterility, and the Mutant Gene in the F_1 Hybrids*

The sterility resulting from a reciprocal translocation between two pairs of chromosomes varies considerably between species. In barley, according to Smith,[7] the sterility usually has been reported to be around 25 percent, although ranging from 15 to 92 percent. In the interchange line under study here, about 19 percent of the florets did not produce seeds (Table IV). This same degree of sterility was observed in F_1 hybrids which received the interchanged chromosomes (Table IV). Pollen abortion was somewhat higher in the mutant line (31 percent) than in F_1 hybrids with the interchange (23 percent). This difference will be studied later.

It is usually assumed that there is a close correlation between pollen and ovule abortion and the frequency of meiotic non-disjunction between adjacent chromosomes involved in an interchange. For that reason an effort was made to determine the frequency of "open" (non-disjunctional) and "zigzag" or "figure-of-eight" (disjunctional) configurations of the chromosomes at first meiotic metaphase in plants heterozygous for the interchange. It is

TABLE III. Chromosomal Configurations and Sterility in F_1 Hybrids, and Segregation of White Seedlings in the F_2.

Cross	F_1 hybrids studied No.	Plants examined cytologically Total No.	R_4 No.	7_{II} No.	Fertility of F_1*	F_1 hybrids segregating white seedlings No.		Frequency
Mutant line ♀ × Compana ♂ F_1	62	31	0	31	Normally fertile	62	550† / 2,646	21%
	73	39	39	0	Partially sterile	0		
Compana ♀ × Mutant line ♂ F_1	192	43	0	43	Normally fertile	192	2,256 / 11,175	20%
	0	0	0	0	Partially sterile	0		

*There was usually no difficulty in distinguishing between normally fertile and partially sterile plants. Those with more than 10 percent sterility were put in the latter class.
†These are of course F_2 populations of seedlings.

TABLE IV. Pollen and Ovule Abortion in Normal Plants, and Plants Heterozygous for the Interchange.

Source of plants	Abortive: Plants studied No.	Abortive: Total florets counted No.	Abortive: Empty florets No.	Abortive: Empty florets %	Abortive pollen grains: Plants studied No.	Abortive pollen grains: Total spores counted No.	Abortive pollen grains: Abortive pollen grains No.	Abortive pollen grains: Abortive pollen grains %
Mutant line	304	33,747	6,230	19	10	18,337	5,667	31
F_1 plants (R_4)	37	3,622	677	19	7	6,642	1,495	23
F_1 plants (7_{II})	46	4,420	26	1	4	2,578	52	2

apparent from Table V that in 40 percent of the pollen mother cells the four chromosomes involved in the interchange appeared to be separating nondisjunctionally. This was true whether the plant under observation was an F_1 hybrid or from the parental line. This frequency was considerably higher than the pollen (20 and 30 percent) or ovule (19 percent) abortion. This anomaly will be the subject of further study.

All of the 39 F_1 plants which were found by cytological observations to have rings of four at meiosis were partially sterile (Table III). Therefore it seemed safe to assume that all partially sterile plants had received the interchanged chromosomes. All of these plants came from crosses in which the mutant line was used as the female parent. Furthermore, none of these plants was heterozygous for the gene for white seedlings.

All of the 74 F_1 plants which were found by cytological observations to have seven bivalents at meiosis were normally fertile and were heterozygous for the mutant gene (Table III). Thus, the gene for white seedlings was not associated with the interchanged chromosomes.

Discussion

The results obtained with the radiation-induced mutant line may be reviewed briefly: (1) In selfed progenies about 50 percent of the plants were green, the rest white. (2) All of the green plants had a ring of four chromosomes plus five bivalents, and were partially sterile. (3) When plants of the mutant line were used as male parents in crosses with a normal variety, all of the F_1's had seven bivalents, were fully fertile, and segregated about 20 percent of white seedlings in the F_2. (4) In the reciprocal cross about half of the plants had a ring of four chromosomes at meiosis, were partially sterile, and did not segregate white seedlings in the F_2. The other half were like (3).

Moh and Smith[3] have suggested a number of ways in which recessive mutants may segregate in ratios which deviate significantly from the usual 3:1. Figure 17 suggests a possible origin of the mutant line by which one of these postulated ways may be used to account for the unusual results obtained in the present study.

No crossover was obtained between any of the three postulated induced changes, i.e., the factor for white seedlings, the factor which affected the transmission of the chromosomes, and the reciprocal translocation. The selfed and hybrid populations were large enough (in the hundreds) to indicate that such crossovers were rare—if they occurred at all.

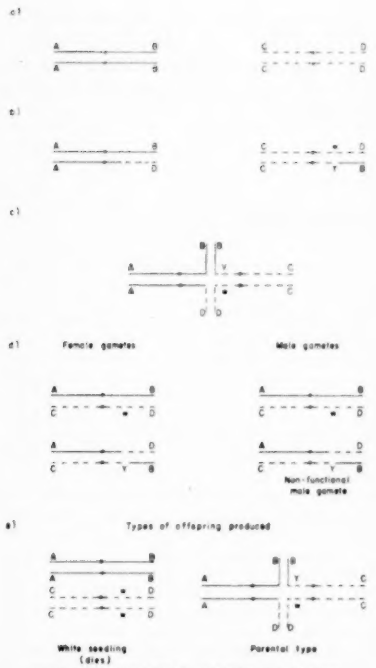
It seems plausible that all three changes may have had interrelated origins. If it were assumed: (1) That the white seedlings were the result of a mutant gene (or possibly a homozygous deficiency or duplication); (2) that the factor which prevented the transmission of the interchanged chromosomes was a deficiency (or a duplication) corresponding to the change resulting in the white seedlings; (3) that the deficiency or duplication occurred at the point of interchange, all of the observed results could readily be accounted for. Until better methods are available, cytological proof for this hypothesis may not be obtained.

Such a series of events might be considered to be highly unlikely. However, it can be observed that about 500 mutations, representing approxmiately 10,000 spikes, grown from irradiated seeds, were tested in finding this particular line. Furthermore, the study of Moh and Smith,[3] and further unpublished data, show that coincidences of two changes (not involving an interchange) practically identical with those here postulated occurred in several other cases. It might also be pointed out that a similar expla-

TABLE V. Chromosomal Configurations in Plants Heterozygous for the Interchange.

Source of plants	Plants studied No.	Cells with indicated chromosomal configuration: Ring of four Open No.	Ring of four Zigzag No.	Chain of four Open No.	Chain of four Zigzag No.	Unclassified*	Total cells observed No.	Open rings of four and open chains of four %
F_1 plants (R_4)	5	119	352	22	40	150	903	40
Mutant line	4	257	243	7	22	127	656	40

*Most of these unclassified cells undoubtedly had zigzag arrangements of the quadrivalent, and were included in that class in calculating the percentage of open rings and chains.



ORIGIN OF THE MUTANT LINE

Figure 17

Postulated origin and constitution of the mutant line. For simplicity only the two pairs of chromosomes involved are represented. There would, of course, be five bivalents in addition. *a*—Two normal pairs of chromosomes before irradiation; *b*—As a result of irradiation, three changes were induced: (1) A mutant factor *W* for white seedlings in a non-interchanged chromosome; (2) a chromosomal interchange; (3) a factor *Y* at the point of interchange, which is transmissible through the eggs but not through the pollen. *c*—Constitution of the X_1 spike produced by the irradiated seed. *d*—Gametes produced by the X_1 spike. *e*—Types of offspring produced.

nation has been accepted for many years to account for results obtained in studies of a number of *Oenotheras*.

Summary

A mutant line of barley was obtained from seeds exposed to atomic bomb-induced radiations at Bikini in which all of the green plants were heterozygous for a chromosomal interchange and for a factor for white seedlings.

In selfed populations 50 percent of the seedlings were white.

In outcrosses on normal plants of the variety, Compana, all of the F_1 plants had seven bivalents and were heterozygous for the factor for white seedlings.

When plants of the mutant line were used as female parents in crosses with Compana, about half of the plants had a ring of four chromosomes at meiosis and did not possess the factor for white seedlings. The other half of the plants had seven bivalents and segregated white seedlings in F_2 as in the reciprocal cross.

The proportion of white seedlings in F_2 progenies of crosses was about 20 percent instead of the 50 percent observed in selfed populations of the original line.

In a study of 1,559 pollen mother cells which were heterozygous for the interchange (from four plants from the original line and three from crosses), about 40 percent of the configurations indicated that adjacent chromosomes in the ring were going together at first anaphase.

Pollen abortion in plants of the original line was about 31 percent; while only about 23 percent of 1,495 pollen grains from F_1 plants were apparently devoid of starch.

There was no appreciable difference in the percentage of empty florets (19 percent) between plants of the original line and of F_1 plants which had the interchanged chromosomes.

Differences between the pollen abortion in plants of the parent line and ring-forming F_1 plants, between pollen and ovule and ovule abortion in the parent line, and between the meiotic chromosome configurations and both pollen and ovule abortion are to receive further study.

It was postulated that the mutant line studied herein arose as the result of a coincidence of three radiation-induced changes: (1) A factor for mutant white seedlings; (2) a chromosomal interchange between two non-homologous chromosomes; (3) a factor in (one of) the chromosomes involved in the interchange which was transmissible through eggs but not through the pollen. Since there appeared to be no crossover between the three changes, it seems plausible that they may be interrelated, and that they possibly occurred at the same locus.

This mutant line might have some usefulness in teaching cytogenetics. Since all of the surviving plants have an interchange, students would be assured of finding a specimen with an interchange for laboratory study.

Literature Cited

1. Cleland, R. E. *Zeitschr. Ind. Abst. und Vererb.* 51:126-145. 1929.

2. McClintock, B. *Proc. Nat. Acad. Sci.* 17:694-698. 1930.

3. Moh, C. C. and L. Smith. *Genetics* 36: 629-640. 1951.

4. SMITH, L. *Jour. Agri. Res.* 63:741-750. 1941.
5. ————. *Stain Tech.* 22:17-31. 1947.
6. ————. *Jour. Hered.* 41:125-130. 1950.
7. ————. *Bot. Rev.* 17:1-51; 133-202; 285-355. 1951.
8. THOMPSON, W. P. and M. G. THOMPSON. *Cytologia, Fujii Jubilee Volume;* 336-342. 1937.

(Received February 11, 1952)

• • •

ULTRA-MODERN GENETICS

TEXTBOOKS of genetics designed to fill various niches have been appearing at a rapid rate in recent years. Srb and Owen have tailored their text to meet the requirements of a one semester course in general genetics.* Moreover, by the selection of appropriate material, the text can be adapted to serve the needs of a variety of courses at the elementary level. The first 16 chapters cover classical genetics. The remaining eight chapters can be given more or less emphasis depending upon the interests of the students. They deal with the details of genetics, population genetics, applied genetics, and there is a final chapter on Genetics and the Welfare of the Human Individual.

The subject matter of each chapter is terminated by a section called, "Keys to the Significance of This Chapter." The terse and penetrating statements under this heading are calculated to be helpful to the student in grasping the fundamental concepts in the material of the preceding pages.

The author's feel, and properly so, that genetics is a problem solving science. In accordance with this thought they have supplied a generous number of well selected problems. These problems run in a graduated series from the relatively simple to the more complex; and should be a source of stimulation to both student and instructor.

At the end of each chapter there is a selected list of references. These items are mostly critical reviews, books, or articles of a general nature from which the literature of a specific topic can be developed. Each reference is followed by pertinent comments that will be useful in guiding the student in the direction of his major interest.

The illustrative materials are generally good. The line drawings of Evan Gillespie are of particular merit. The photographs are well chosen and equally well reproduced. The three dimensional diagrams illustrating meiosis, and redrawn from Sharp are quite realistic, but several have become a trifle indistinct as a result of using this technique.

The reviewer is not entirely in sympathy with several features of the book. In their enthusiasm to include the latest developments in present day genetics, the historical foundation of the subject has been neglected. In fact, the student may be left with the erroneous impression that all of the important discoveries in genetics were made within the past decade. A scholarly account of the researches of the early hybridizers and the biologists of the pre-Mendelian era would have added much to the book. But even the fundamental contributions of Bateson, Correns, McClung, and Sutton reported in the early years of the present century are omitted.

The chapter on, "Genetics and Evolution" might have been enlarged to mention the concept of introgressive hybridization developed by Edgar Anderson, or the classical work of Babcock and his colleagues with *Crepis* and the monumental experimental evidence on the evolution of species in nature, gathered by the Carnegie group at Stanford. Likewise, some discussion of Simpson's data on rates of evolution would have been pertinent. However, limitations of space probably forced the authors to exercise a choice of the material to be included. These omissions are a clear indication that the principles and important implications of genetics can no longer be compressed into a single volume, even though it runs to 561 pages.

Mechanically the book is exceptionally well done. The attractive format, good paper, clear and easily read print, few typographical errors, and accurate index are a tribute to both the authors and the publisher.

In spite of minor inequalities Srb and Owen have done a remarkably competent job of presenting the basic principles of genetics. With the customary pedagogical assistance from the instructor, there is no doubt that the serious student would have a thorough knowledge of the subject matter of genetics, should he elect to absorb the information contained in this textbook.

THOMAS W. WHITAKER

U. S. Department of Agriculture
La Jolla, California

**General Genetics.* ADRIAN M. SRB AND RAY D. OWEN. i-x, 1-561, f. 1-1 to 26-4; pl. 1-2. W. H. Freeman & Co., San Francisco, California. 1952. $5.50.

STEELBLU, AN ALLELE OF PLATINUM

In the Ranch Mink*

RICHARD M. SHACKELFORD†

THE first mutant color phase of the black-brown ranch mink (*Mustela vison* sp.—Figure 18*A*) to become established in the fur trade was Platinum (Figure 18*C*). This color is most often described as blue gray, but perhaps a better term would be metallic or pearl gray. The clearness of the gray color varies widely in Platinums, depending for the most part upon the residual inheritance. Shackelford[2] and Smith *et al.*[4] have shown that Platinum is inherited as a simple recessive to non-Platinum, the latter authors having used p to symbolize the autosomal recessive gene.

Several years after the Platinum mink had come to be bred in considerable numbers, a darker gray color phase appeared on various ranches and was found to be inherited as a recessive character. The most common name applied to this color was Steelblu (Figure 18*B*), although other names have been used: Steel, Heather and the "Gunmetal Blue" mentioned by Castle and Moore[1] are most probably different appellations for the same genotype.

Breeding records from a number of commercial ranches revealed that Steelblu × Platinum matings produce litters of two types. Some were composed entirely of Steelblu kits, while others contained both Steelblus and Platinums. This information led a number of workers, including Shackleford,[3] to suggest that a gene for Steelblu, p^s, was an allele of p. However, as the number of mutant color mink increased, it was common for light individuals to appear on ranches having only Steelblus which could be confused easily with the darkest Platinums on other ranches. Furthermore, in some herds where there had been considerable interbreeding with these two color phases, a clear-cut dividing line between Steelblu and Platinum could not be established. These observations made it seem plausable to consider the alternative possibility that Steelblus and Platinums were both homozygous for p, and that mink classified as Steelblus were darker in color as a result of modifying genes working on the Platinum genotype. Critical evidence is presented here to show that p and p^s are members of an allelic series.

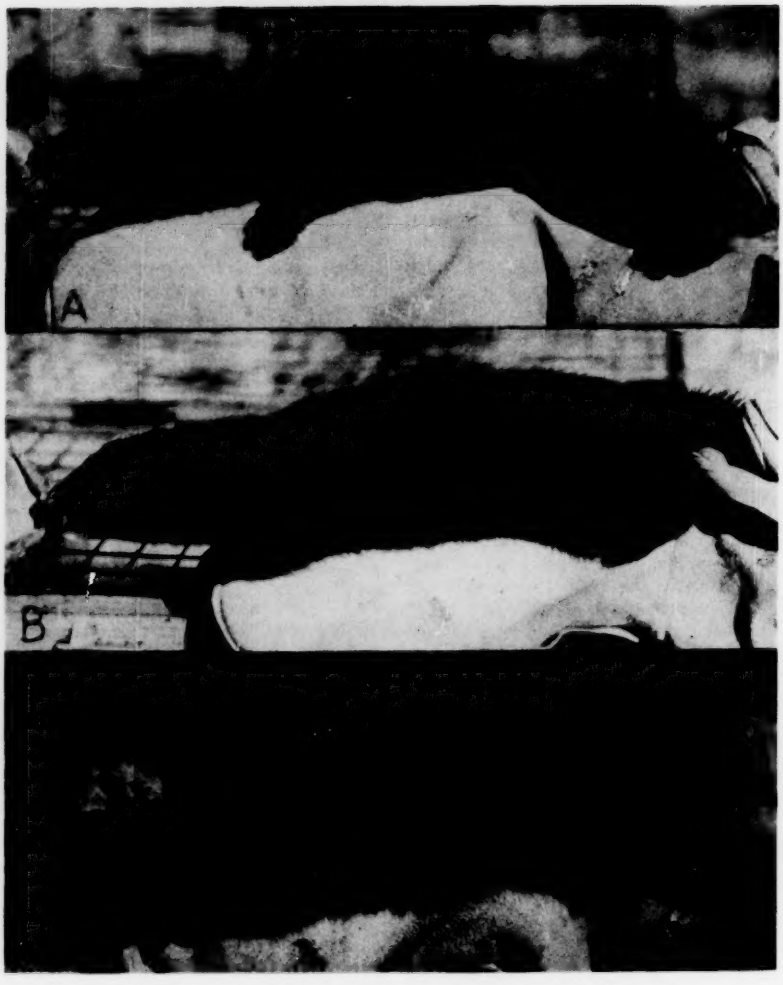
Breeding Experiments

A Steelblu male mink was obtained in 1947 by this laboratory for use in connection with breeding experiments involving the inheritance of a character other than color phase. He was mated to three Platinum females, and three Dark (wild type) females known to be heterozygous for p. These six matings resulted in a total of 10 Platinum and nine Steelblu offspring (in addition to Darks), indicating that the Steelblu male was producing approximately equal numbers of kits of these two mutant color phases as would be expected from such matings if he were heterozygous. In addition, if this Steelblu male were heterozygous for allelic genes, the gene for Steelblu must be dominant to the gene for Platinum since his color was Steelblu and not Platinum. The mutant color phase kits only are diagnostic, so the Dark kits require no further consideration for the point under discussion.

It was obvious, however, that these Dark kits from the Dark (Pp) mothers were excellent material for a more rigorous test of whether or not two genes are responsible for Platinum and Steelblu. The Dark color of the kits indicate that the mothers have contributed P. So, if two different allelic mutant genes were involved the Dark kits would have in-

*Cooperative experiments between the Wisconsin Conservation Department's Experimental Game and Fur Farm, Poynette, and the Department of Genetics (Paper No. 483), University of Wisconsin. Published with the approval of the Director of the Wisconsin Agricultural Experiment Station.

†Genetics Department, University of Wisconsin and Bureau of Animal Industry, U. S. Department of Agriculture.



WILD TYPE AND TWO MUTANT COLOR PHASE MINK

Figure 18

A—The natural dark (wild type—*PP*) ranch mink. *B*—Steelblu ($p^s p$), a dark gray color phase. *C*—Platinum (pp), the light gray color phase which was the first of the mutant colors to be produced in quantity.

herited one or the other, but not both, from the Steelblu male parent.

The following year four Dark males and one Dark female from the matings just described were bred to a group of Platinums to test the hypothesis that each had inherited either p or p^s from their Steelblu parent. Male No. 37 was the only Dark offspring from one of the Dark females, while the other three males (Nos. 34, 35, and 36) and the female (No. 91) were litter mates. During this breeding season (1949) male No. 37 produced four litters in which the mutant kits totaled 11, all Platinum. The four litter mates produced as follows: Male Nos. 34 and 35 gave three litters each, the mutant kits totaling 10 and three respectively, all Steelblu; male No. 36 sired four litters with a total of eight mutant kits, all Platinum; female No. 91 had only one mutant kit in her litter and it was a Platinum.

The 1949 breeding results from these Dark mink indicated that two of them (Nos. 34 and 35) were heterozygous for the gene for Steelblu (p^s) and three (Nos. 36, 37 and 91) heterozygous for the gene for Platinum (p). The possibility remained that certain of the Platinums used may have harbored modifying factors which, together with similar modifying factors from mink Nos. 34 and 35, had a cumulative effect and caused kits of the genotype pp to be classified as Steelblus. To test this point, in the 1950 breeding season an effort was made to place Platinums that had produced Platinum kits the year before with Dark individuals giving only Steelblu kits the previous year, and vice versa. Thus, females Nos. 83, 98, 102, 88 and 95 gave kits of one mutant color one year and the other mutant color the following year. Female No. 92 was bred to a different "Platinum siring" male the year previously and was consistent in producing only Platinum kits in 1950, while female No. 93 gave Platinums both years by the same Dark male. Dark female No. 91 was mated to different Platinum males each year, and produced only Platinum offspring. Male Dark 35 died before the 1950 breeding season.

Conclusion

All of the Dark mink from Table I were consistent in producing either Platinum or Steelblu offspring when the appropriate breeding tests were made as indicated. This is taken as conclusive evidence that in the ranch mink two allelic genes, p and p^s, are responsible for the color phases Platinum and Steelblu, respectively. The data show further that the Steelblu male was heterozygous for p; therefore, the order of dominance is $P \rightarrow p^s \rightarrow p$.

Mention was made earlier in this report that no clear-cut dividing line could be established between some of the lightest individuals known to be genetically Steelblu and dark Platinums. At the other end of the range in coloring, Steelblus can be so dark that they cannot be distinguished from Dark (wild type) mink except in bright light. With a heterogeneous background of modifiers such as exists in most ranches, the genotypes $p^s p^s$ and $p^s p$ are of the same phenotype (Steelblu). However, it is possible that these two genotypes could be differentiated with regularity if a more homogeneous background of modifiers were provided.

TABLE I. Results of Testing Dark Mink for Heterozygosity for Either the Gene p or p^s.*

Sex, Number & Color Phase of Mink Tested	1949 Sex, Number & Color Phase	1949 Number & Color Phase of Mutant Kits Platinum	1949 Steelblu	1950 Sex, Number & Color Phase	1950 Number & Color Phase of Mutant Kits Platinum	1950 Steelblu
♂ Dark 34	♀ Platinum 83	0	4	♀ Platinum 88	0	4
	" 97	0	3	" 95	0	3
	" 105	0	3	" 111	0	2
				" 133	0	1
♂ Dark 35	♀ Platinum 84	0	1			
	" 98	0	1	died January 17, 1950		
	" 102	0	1			
♂ Dark 36	♀ Platinum 86	1	0	♀ Platinum 93	3	0
	" 92	4	0	" 153	3	0
	" 93	2	0			
	" 103	1	0			
♂ Dark 37	♀ Platinum 45	3	0	♀ Platinum 83	1	0
	" 88	1	0	" 92	3	0
	" 95	4	0	" 98	4	0
	" 104	3	0	" 102	6	0
♀ Dark 91	♀ Platinum 17	1	0	♀ Platinum 39	4	0

*The expectation for this type mating is one Dark (heterozygous for p or p^s) to one Mutant (either Platinum or Steelblu). The dark kits have been omitted since they are non-diagnostic.

Literature Cited

1. Castle, W. E. and Larry Moore. *Jour. Hered.* 37:137-145. 1946.
2. Shackelford, R. M. *Trans. Wis. Acad. Sci., Arts and Lett.* 34:45. 1941.
3. Shackelford, R. M. Genetics of the Ranch Mink, 91 pp. Illus. New York, Pilsbury Publishers, Inc. 1950.
4. Smith, S. E., C. H. Whitaker, Leo F. Davids and Percy V. Noble, *Jour. Hered.* 32:173-176. 1941.

(Received April 21, 1952)

Hereditary Disease Responds to Estrogen Therapy

THE use of a female sex hormone substance to control a usually fatal bleeding disease was recently reported by a team of scientists from the Sloan-Kettering Institute of Cancer Research and the Memorial Center for Cancer and Allied Diseases.

The disease is hereditary hemorrhagic telangiectasia, also known as Osler-Rendu disease. It has not responded successfully to x-ray treatment, radium surgery, use of snake venom to increase blood coagulability or the so-called vitamin P. Thus, the new therapy of using hormone substances may take the disease out of the class of incurable.

It has no connection with hemophilia, nor is it cancer.

The hereditary cause of the condition, which is passed on by either male or female, brings about small tumor-like knots of blood vessels on any of the mucous membranes or anywhere on the external surface of the body. They are known as telangiectases. The incidence of the disease is believed to be higher than reported cases indicate.

The Sloan-Kettering and Memorial scientists reported their findings with the use of the hormone substance in a preliminary report published in the August 9 issue of the *Journal of the American Medical Association.* The report, a preliminary one, was written by Drs. Henry J. Koch, George C. Escher and John S. Lewis. Dr. Koch is a scholar of the American Cancer Society and also an Alfred P. Sloan Foundation Fellow.

The preliminary report was based on five patients, three women and two men. All were over 40 years of age.

In the scientists' clinical summary, they pointed out that the most common symptom of the disease is bleeding from the nose, a condition known technically as epistaxis. They said, however, that other mucous membranes or the skin may be the exclusive sites of hemorrhage, and that "an anemia often results from the long continued blood loss, and fatal hemorrhages have occurred."

The telangiectases, or tumor-like knots of blood vessels, usually do not appear before the age of puberty, the doctors said, and in the third and four decades of life "they become more numerous and more subject to hemorrhage." Death usually has been the result of the disease.

"No single therapeutic agent or surgical approach, or a combination of them, has consistently decreased the incidence or severity of recurrent hemorrhage," the doctors said.

The first patient to receive the new therapy was a 44-year-old unmarried woman, being admitted to Memorial Center on December 13, 1950, after a long illness caused by the disease. The doctors decided to try estrogen, a female sex hormone, because of an apparent long relationship between recurrent nose bleeding and the menstrual cycle. Moreover, the disease became much more severe after an artificial menopause had been produced, which in turn caused a decrease in the manufacture of female sex hormones by the patient.

In summary, the doctors reported:

"The clinical response of the nasal mucosa to estrogen therapy is a return of the mucosa to a moist and vascular appearance. In our experience this change has occurred from one to three weeks after treatment has been initiated. Concomitant with the changes in the nasal mucosa the epistaxes (nose bleeding) are decreased in number and severity to the point of only occasional spotting. The telangiectases disappear in the nasal passage. The cutaneous lesions blanch and diminish in size. It would appear that similar changes have occurred in the intestinal tract as evidenced by a disappearance of tarry stools. The prompt relapse after cessation of therapy suggests that continuous treatment is necessary to maintain the favorable response."

The doctors said that the mechanism by which estrogen therapy has helped in the bleeding disease "cannot be explained at the present time," but that studies are under way to determine the action.

"It is possible that estrogen, by restoring the normal texture of the nasal mucous membranes, protects the telangiectases from trauma and subsequent bleeding," the doctors reported.

—Sloane-Kettering Institute News Release

GENETIC FOOTNOTES

Fundamental Concepts of Genetics

Dr. E. B. Babcock reviews the seven highlights of the first half-century since Mendel's paper was rediscovered. The bibliography includes the contributions of over a hundred geneticists.

—60c per copy; $4.80 per doz.

Mendel Issue— Journal of Heredity

This issue contains a facsimile reproduction of Mendel's "Experiments in Plant Hybridization" exactly as it appeared in the Verhandlungen Naturforschender Verein in Brunn, Vol. 4, pp. 3-47.

—50c per copy

Meiosis in Maize

Charts and photographs illustrating the different stages of meiosis. 12 pp.

—20c ea.; $1.25 per dozen

Order from:

AMERICAN GENETIC ASSOCIATION
1507 M ST., N.W., WASHINGTON 5, D. C.

GENES AND MUTATIONS

Cold Spring Harbor Symposia on Quantitative Biology

Volume XVI (1951), 540 quarto pages, with numerous figures

Authoritative reviews of the gene problem, presented in 35 papers and edited discussions. Subjects considered are: theory of the gene, cytoplasmic constituents of heredity, evolution of the gene, induction of changes in genes and chromosomes, genetic mechanisms in bacteria and bacterial viruses. Table of contents sent on request.

Previous volumes still available: IX (1941) Genes and Chromosomes; XI (1946) Heredity and Variation in Microorganisms; XII (1947) Nucleic Acids and Nucleoproteins; XIII (1948) Biological Applications of Tracer Elements; XIV (1949) Amino Acids and Proteins; XV (1950) Origin and Evolution of Man.

Prices: Volume XVI, $9.00; other volumes, $7.00. Volumes IX and XVI, or XV and XVI, $14.00; volumes IX, XV, and XVI, $20. Postage extra; domestic, 25 cents, foreign 50 cents per volume.

ADDRESS: BIOLOGICAL LABORATORY
COLD SPRING HARBOR, NEW YORK

Just Published

A NEW REVISED EDITION

PREFACE to EUGENICS

BY FREDERICK OSBORN

Presents a working hypothesis on which to base a voluntary, democratic, and practical program of eugenics, complementing all other efforts toward social advance.

"It pulls together the more valuable information that the geneticists, psychologists, anthropologists and population experts have gathered in the last fifty years; it disposes of the snobbish pretense that there is a eugenic difference between the average members of upper and lower social and economic classes. . . . A notable contribution." WALDEMAR KAEMPFFERT, *The New York Times Book Review*

HARPER & BROTHERS New York 16, N. Y. *333 pages* **$4.00**

POPULATION STUDIES

A Journal of Demography

Editor, D. V. GLASS

Vol. VI, No. 1 **July, 1952**

CONTENTS

CICELY WATSON. Recent Developments in French Immigration Policy.

H. BERNARDELLI. New Zealand and Asiatic Migration.

H. SILCOCK. Estimating by Sample the Size and Age-Sex Structure of a Population.

D. V. GLASS. The Population Controversy in Eighteenth-century England. Part I. The Background.

KENNETH SMITH. Some Observations on Modern Malthusianism.

S. W. CAFFIN. Infantile Mortality Rates.

Book Reviews.

Books and Publications Received.

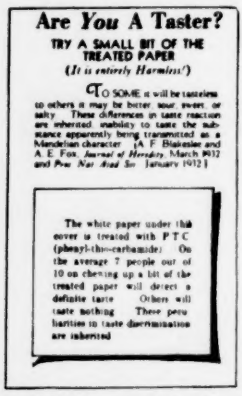
Letters to the Editor.

Subscription price per volume of 3 parts, $5.00

Published for the POPULATION INVESTIGATION COMMITTEE by

CAMBRIDGE UNIVERSITY PRESS

32 East 57th Street, New York 22


Are You A Taster?
TRY A SMALL BIT OF THE TREATED PAPER
(It is entirely Harmless!)
TO SOME it will be tasteless to others it may be bitter, sour, sweet, or salty. These differences in taste reaction are inherited, inability to taste the substance apparently being transmitted as a Mendelian character. (A. F. Blakeslee and A. E. Fox, Journal of Heredity, March 1932 and Proc. Nat. Acad. Sc. January 1932)
The white paper under this cover is treated with P T C (phenyl-thio-carbamide). On the average 7 people out of 10 on chewing up a bit of the treated paper will detect a definite taste. Others will taste nothing. These peculiarities in taste discrimination are inherited

LEAFLETS TO DEMONSTRATE HEREDITY

Last year the "Taster test" served as an introduction to human genetic differences in many classrooms. The test is so easily made with the treated paper, and arouses such great interest that it appears to have a definite place in group demonstrations of such differences. These leaflets, size 3⅜" by 5½", are available in quantities for those who wish to use them for classroom or lecture purposes. On the back is printed an outline 4-generation pedigree chart. Sample on request. Prices: 10 for 25c; 50 for $1.00.

AMERICAN GENETIC ASSOCIATION

1507 M STREET, N. W. WASHINGTON 5, D. C.